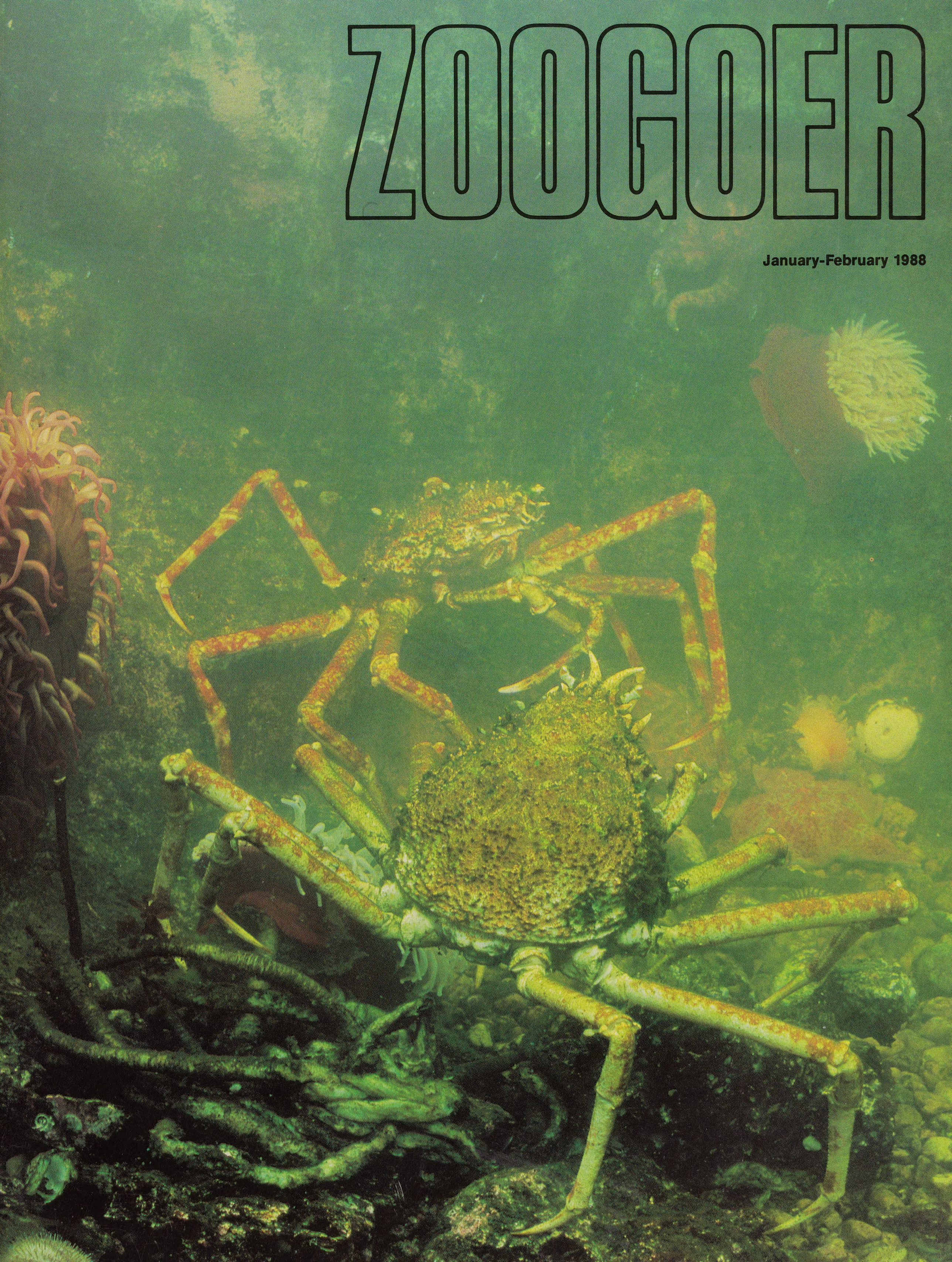
ZOOGOER

January-February 1988



Friends of the National Zoo

is a nonprofit organization of individuals, families, and organizations who are interested in helping to maintain the status of the National Zoological Park as one of the world's great zoos, to foster its use for education, research, and recreation, to increase and improve its facilities and collections, and to advance the welfare of its animals.

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Cover: Japanese giant spider crabs (front cover) and an orangutan with newborn (back cover) at the National Zoo. **Centerspread:** A female trumpeter swan. Photos by Jessie Cohen, NZP Graphics.

NEW BEGINNINGS

The new year marks an important milestone for the Friends of the National Zoo, which celebrates its 30th birthday in April. 1988 also brings a number of new beginnings: George Didden, III, was recently elected president of FONZ; the expanded Bookstore is open for business; *ZooGoer* has a new editor; and FONZ is giving new emphasis to providing support for all the living things—plants as well as animals—that will populate our evolving Biopark.

At middle age, FONZ has matured into an organization that ranks as one of the best of its kind. FONZ's 24,000 memberships, which include more than 50,000 people, make it one of the largest zoo support organizations in the world; its 400-plus volunteer force serves the National Zoo and its mission of education, research, recreation, and conservation in ways too numerous to mention; and its funds send Zoo scientists around the globe to conduct research that will affect the fate of endangered species and habitats.

Today, FONZ is still driven by the same zeal that in 1958 inspired a group of concerned citizens to band together to support NZP's aims and objectives and to help maintain its status as one of the world's great zoos. Through its publications, through its outstanding educational programs for adults and children, through the sale of fascinating natural history books and merchandise, FONZ strives to communicate the vital importance of conserving and protecting the earth's living resources, in the zoo and in the wild.

Yet equally important is the financial support that FONZ plans to continue to offer the Zoo in an era of fiscal austerity. These funds are raised through the day-to-day parking and concession operations and supplemented by special programs like A.D.O.P.T., which provides extra support for the Zoo's animal programs, and ZooFari, the annual benefit which helps bring new and exciting animals to the Zoo. This year's ZooFari theme—Australia—was chosen in part to celebrate the country's 200th birthday and the proceeds may help to bring more of Australia's unique animals to the National Zoo.

As members of FONZ, we can all be proud of our support for the Zoo's exhibit, education, research, and conservation programs. Working together, the National Zoo has become one of the world's great zoos and FONZ one of the zoo world's best "friends." As we move toward the National Zoo's Centennial in 1989, I look forward to a great future for this unique partnership.

Sanders Lewallen
Executive Director

OUR NEW BOOKSTORE

offers a complete selection of natural history books, including some noted in this issue of *ZooGoer*:

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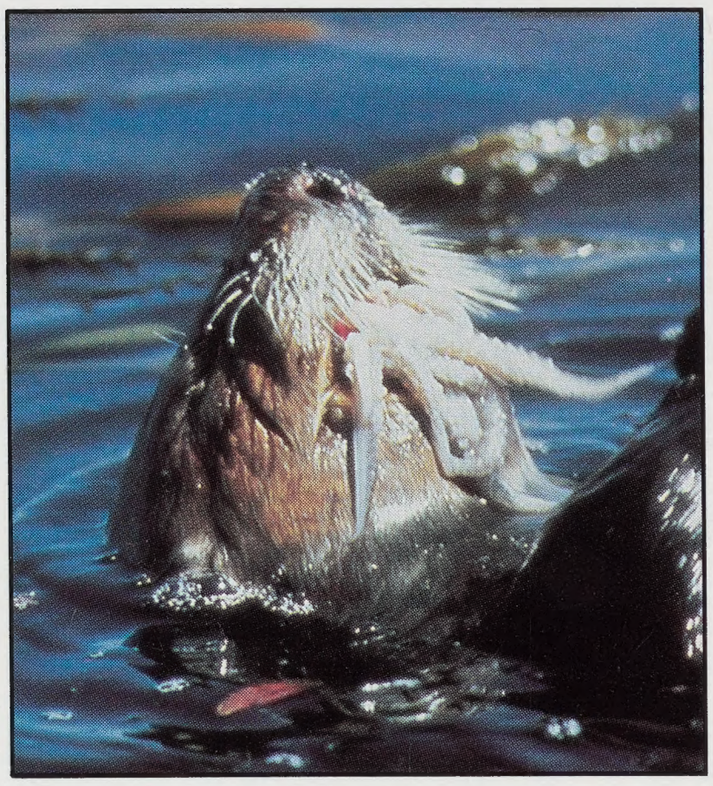
The Bookstore is in the Education Building at the National Zoo. Winter hours are 10 a.m. to 4 p.m. daily. Mail and telephone orders are gladly accepted. Please call 673-4967 for more information.

Richard Bucich



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Jessie Cohen, NZP Graphics

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Sea Otters Gone South

Southern Californians have missed the joys of watching sea otters frolic in coastal kelp beds since the early 1900s. Now the otters are back, at an island 75 miles west of Los Angeles.

Robin Meadows

A brown sea otter basks in the afternoon sun. One minute, the four-foot, 60-pound otter bobs in the ocean waves as if he were just another piece of kelp, and the next minute he's gone, diving for food. Fifty seconds later, the otter shoots back to the surface and flips over on his back. Taking a sea urchin from his armpit, the otter settles down to enjoy his meal.

This otter is one of 60 that U.S. Fish and Wildlife Service (USFWS) biologists recently moved from central California to San Nicolas Island. Coordinated by USFWS biologist and Smithsonian Research Associate Robert L. Brownell, Jr., about 50 people caught, cared for, and transported the otters in the fall of 1987. Assisting with the translocation effort was NZP biologist Katherine Ralls, who has been studying the behavior and demography of the central California sea otters for four years with Donald Siniff from the University of Minnesota.

USFWS biologists established a group of California sea otters (*Enhydra lutris*) at San Nicolas Island because the main population is endangered. About 1,700 otters live along only 250 miles of the central California coast, and many USFWS biologists fear that a large oil spill could contaminate the entire range. This could decimate the main population, leaving the remaining otters vulnerable to another catastrophe.

The sea otter's present range and population are much smaller than they used to be. In the mid-1700s, about 200,000 otters flourished along the Pacific coast, all the way from central Baja California, Mexico, through the Aleutian Islands; the state of California alone had nearly 20,000.

Then, people began hunting the otter for its luxurious fur. By 1900, so few California otters were left alive that people thought they were extinct. Fortunately, about 50 otters were still living off Point Sur (about 150 miles south of San Francisco) and in 1913 California passed a law protecting them.

About 1,300 otters in Alaska also eluded the fur hunters, and, unlike the California population, the Alaska population is now booming. Today, there are about 150,000 otters living along the Alaskan coast—so many that Southern California shellfishermen thought the USFWS didn't need to move any otters to San Nicolas Island. The fishermen argued that if an oil spill killed the California otters, the USFWS could just replace them with Alaskan otters. However, the issue is not that simple. According to USFWS biologist and former NZP post-doctoral fellow Galen Rathbun, the Alaskan otters may well differ genetically from those in California. Moreover, the California population, by law, must be protected.

Due to the risk of oil spills, the USFWS classified the California sea otter as "threatened" in 1977. Under the 1973 Endangered Species Act, animals that could become extinct in the near future are "endangered," while those that could become endangered in the near future are "threatened."

USFWS biologists decided that the best way to protect the otter would be to establish a second population at least 100 miles away from the central California otter range. Then, a single oil spill would be extremely unlikely to destroy both groups of sea otters. However, fishermen opposed the USFWS plan, because an adult otter can eat 15-20 pounds of shellfish a day. Unfortunately, wherever the USFWS introduced them, otters would affect the local shellfisheries.

To compromise with the fishermen, the USFWS agreed to limit the new otter population to a small area. They chose San Nicolas Island because it has a relatively low risk of oil spills, and because introduced otters would have the smallest impact on local fisheries. In addition, the rest of southern California will remain free of otters, as USFWS biologists will return stray otters to either San Nicolas Island or the present range.

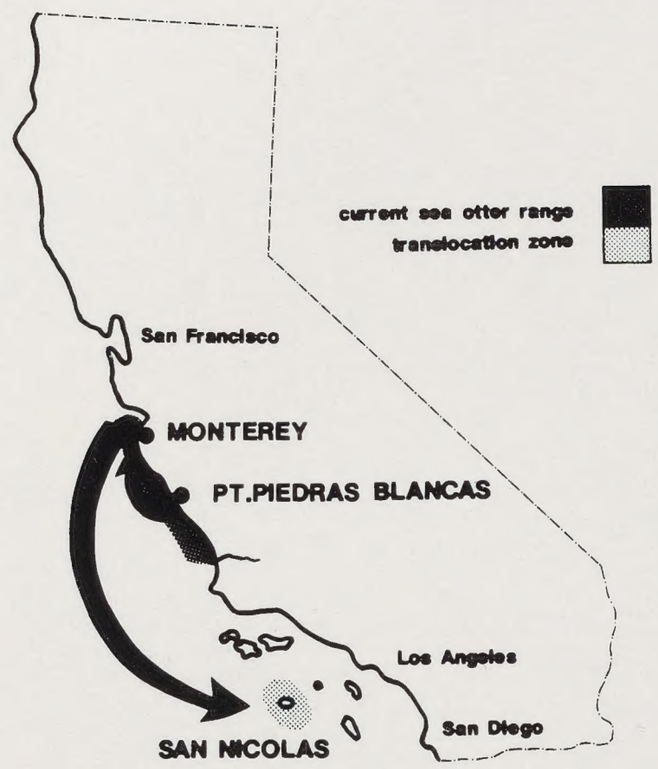
While they will eat just about any kind of shellfish, otters, like people, prefer abalone, crabs, and sea urchins. Otters usually hunt within a mile of the shore, where the waters are less than 100 feet deep and shellfish abound. In order to produce enough body heat, the sea otters eat an amount of food equivalent to about 25 percent of their body weight a day. Lacking the blubber that keeps other marine mammals warm in the ocean, otters rely instead on an insulating layer of air trapped in their thick fur. When oil coats an otter's fur, it destroys this air layer and the otter dies of hypothermia.

About 70 percent of oil spills come from tankers, and each year, tankers carry about 94 million barrels of oil past the main otter range. While there have been no major oil spills in central California waters, there have been several along other parts of the coast. One of the worst oil spills was in 1984,

Robin Meadows is a California-based freelance writer specializing in science and the environment.

The sea otter (right) retains body heat by trapping air in its thick fur. Oil destroys the animal's insulation, often causing hypothermia and death. (Photo by Richard Bucich.)

Sriyanie Miththapala



Richard Bucich

Sea otters eat their food while floating on their backs.

when a tanker called the *Puerto Rican* exploded near San Francisco. The *Puerto Rican* was carrying more than 100,000 barrels of oil, and biologists found oil-contaminated wildlife more than 100 miles north of San Francisco.

When oil spills in the ocean, local currents and wind speeds determine how far it spreads. If the *Puerto Rican* had exploded in the present sea otter range, the oil it spilled might have contaminated the entire 250-mile range, according to the controversial work of USFWS biologists Glenn Van Blaricom and Ron Jameson.

In 1978, VanBlaricom and Jameson studied lumber spilled from a ship 60 miles off the central coast. The amount of lumber was equivalent to nearly 30,000 barrels of oil, and the researchers found that the spilled lumber spread at about the same rate as spilled oil. In four weeks, the lumber had spread throughout the current otter range. Thus, if this lumber ship had been an oil tanker, oil could have contaminated many or most of the California sea otters.

Protecting the otters is important because a robust population reflects a healthy coastal environment. According to VanBlaricom, otters may play a key role in stabilizing kelp forests, which are nurseries for many fish, including several commercial species of rockfish. Otters help preserve the kelp forests by eating sea urchins, which in turn eat kelp. Urchins usually eat pieces that fall off the plants, but when a heavy storm washes away the kelp pieces, the urchins may devour the living plants. Unchecked, hungry urchins can destroy a kelp forest, leaving the ocean floor barren. Otters keep the urchins in check.

The new population at San Nicolas Island will provide a test of Van Blaricom's theory that otters enhance kelp growth and thus increase finfish populations. Since 1980, biologists have studied the marine plants and animals along the island's coast. Now, researchers will be able to monitor how the introduced otters affect the abundance and distribution of nearshore flora and fauna.

Three crews of biologists worked on transporting the otters to the island from late August to early November 1987, before the winter storms made the seas too rough. The first crew, led by Rathbun, captured otters; the second, led by VanBlaricom, cared for the otters in their temporary quarters at the Monterey Bay Aquarium; and the third, led by USFWS biologist James A. Estes, brought the otters from Monterey and released them at San Nicolas Island.

The capture crew searched for sleeping otters in the rough waters around Point Piedras Blancas, a USFWS research station near the middle of the sea otter range that also serves as a base for the Ralls and Siniff sea otter study. Working in teams of three to a boat, the crew scooped up otters lying in open water with dip nets and used handheld traps to capture those feeding in kelp beds. Four teams caught otters and a fifth shuttled them to shore.

Then, the moving crew took over. Ralls, one of the team members, drove the first vanload of otters to the Monterey Bay Aquarium, a two-hour-plus trip along the winding, cliff-lined coast. There, she helped tag the otters' hind flippers with two-inch strips of brightly colored plastic: males got chartreuse and females got pink on one flipper, while the color on the other flipper varied for individual identification.

To tag the otters, the crew punched small circles out of their flippers. Ralls then helped preserve the tissue for future genetic studies, working with Mary Eichelberger from Stephen O'Brien's laboratory at the National Cancer Institute. (O'Brien, an NZP Research Associate, has done genetic analyses of many animals, including the NZP giant pandas: In 1983, he determined the paternity of Ling-Ling's cub after she mated with her mate Hsing-Hsing, but received semen via artificial insemination from the London male panda Chia-Chia.)

By analyzing the flipper tissue, researchers will be able to characterize each captured otter's genetic makeup because all the cells in an animal have a complete set of genes. Thus, researchers will be able to assess the new otter population's genetic variability. This diversity is important to the survival of small populations, as Ralls has shown in her NZP studies relating inbreeding to

infant mortality. In addition, analyzing the otters genetically will allow researchers to follow the new population's lineage. This will help determine whether dominant males father most of the first pups.

Besides helping to tag the otters and prepare flipper tissue for genetic studies, Ralls assisted the volunteers who monitored the captured otters around the clock at their half-way house in the Monterey Aquarium. The volunteers made sure each otter was healthy and eating well, and kept track of which individuals associated with each other. On the basis of these interactions, the team decided which otters should be housed together prior to their release at San Nicolas Island.

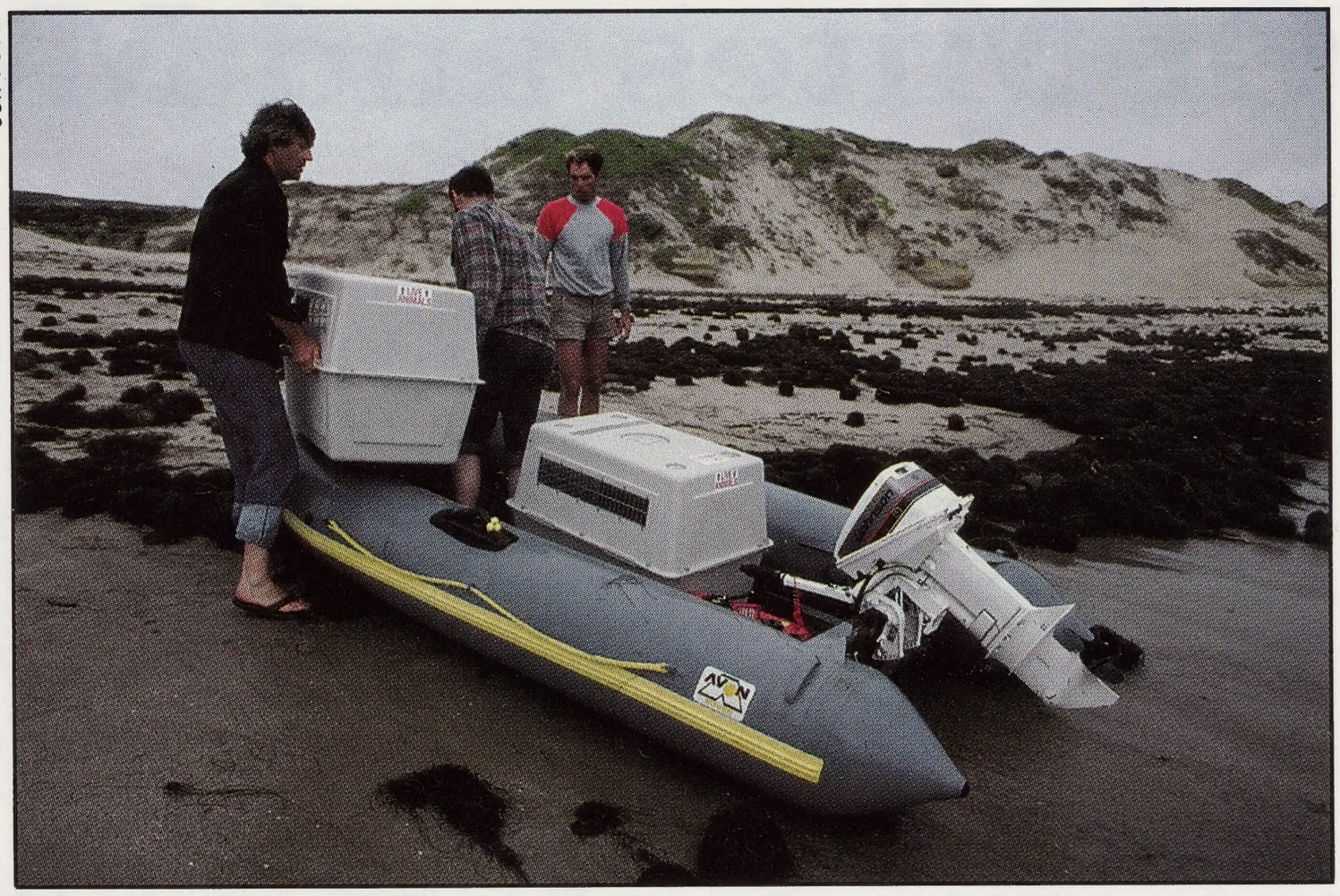
The USFWS flew most of the captured otters to the island's Navy landing field in eight batches numbering from one to 24 animals each. To acclimate the otters to their new home, the release crew kept them in netted ocean pens measuring 12 feet on each side. Each pen held about eight otters apiece, and after a few days, the crew opened the netting to allow the otters to swim out at will.

The success of the new population will depend largely on whether or not the otters stay at San Nicolas Island. USFWS biologists chose the island in part because it is surrounded by at least 45 miles of 1,200-foot deep waters. Sea otters can't dive for food in water that deep, so the biologists predict that the otters will hug the shellfish-rich island shore.

To monitor the new population, the USFWS has a permanent staff of biologists at San Nicolas Island. These biologists observe the sea otters daily, using high-powered telescopes to identify individuals from the colored tags on their hind flippers. Although it is often difficult to see these tags, as the otters can be in thick kelp beds at a considerable distance from shore, the otters seem to have taken to their new home.

Besides protecting the California sea otter from future oil spills and giving researchers the opportunity to answer questions, the new otter population at San Nicolas Island will give southern Californians a taste of what their environment was like before humans intruded. □

Jeff Foott



Jeff Foott

Richard Bucich

Biologists load two sea otters aboard a rubber boat at San Nicolas Island (top). A sea otter is released from its kennel into a holding pen (middle). Two sea otters float free in the wild (bottom).

Of Mites and Men

Susan Weinberg

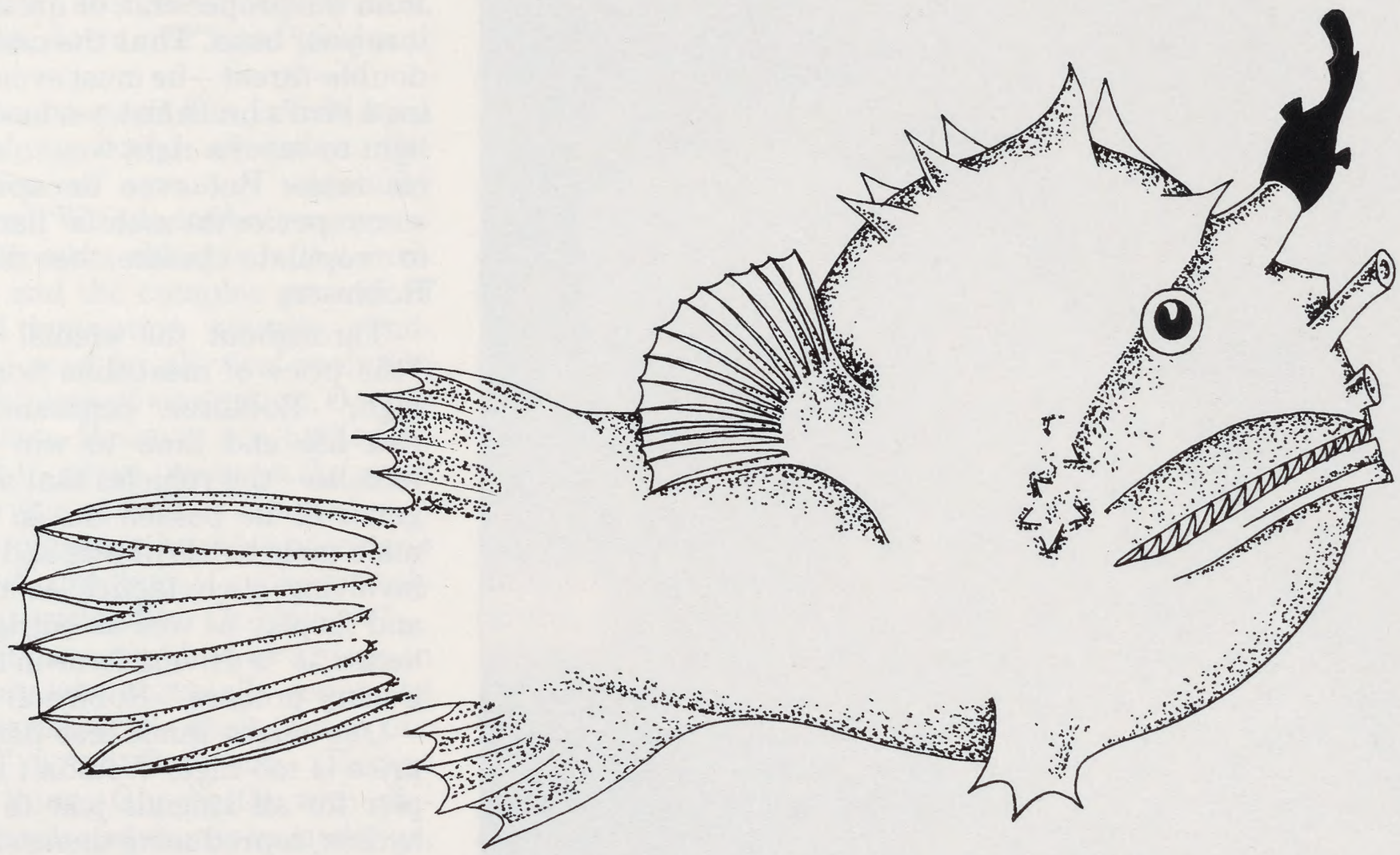
At first, scientists studying a species of deep-sea angler fish (*Photocorynas sprinceps*) wondered about the strange little warts on many angler females. And why, they no doubt also wondered, did they only find female anglers?

The answers became clear when the scientists took dissecting tools in hand and focused their microscopes for a closer look at the mysterious "warts," which turned out to be the males of this angler species! Its body little more than a tiny sex organ, the male lives as a parasite, attached forever to his female host and mate.

While hardly a portrait of masculine splendor, the male angler's role in this species does make good evolutionary sense. These angler fish are creatures of the vast ocean depths, where the chances of encountering prospective mates are unlikely at best. By affixing himself to the female for life, the unobtrusive *Photocorynas sprinceps* male at least ensures that he will be in the right place at the right time for mating.

Such sexual parasitism is but one of the surprising strategies that male animals employ in the never-ending struggle to obtain mates and father young, according to National Zoo Director Michael Robinson.

Following the blueprint of nature, males of many plant and animal species go to astonishing lengths to beat the competition and pass their own genes on to the next generation. While we are accustomed to thinking of this phenomenon in terms of the



This parasitic male angler fish, shown in black, attaches himself to the larger female for life. (Drawing by Sriyanie Miththapala.)

macho clashing of antlers or baring of teeth as males challenge each other for access to females, Robinson explained that equally elegant, and perhaps more subtle, reproductive strategies are used by the "humble" and often diminutive males of the invertebrate and aquatic worlds.

For example, the male giant wood spider (*Nephila maculata*), only 1/300th the weight and one-tenth the size of the female he courts, first calms the female (who could easily attack and make a meal of the male, if she chose) by binding her with silk. Following the mating, the male attempts to ensure sole paternity of the female's numerous young by sealing the female's sex opening with a waxy plug that prevents any other male from mating with that female. The fate of the offspring is literally sealed—the one-time mating will last the female the rest of her reproductive life, enabling her to produce fertile eggs every 21 days for the next six months.

A functionally similar maneuver is employed by the Javanese stick insect (*Orxines macklotti*), which prevents other males from having access to the female by remaining in the mating position for several days.

But ensuring paternity is only part of a male's reproductive strategy, for males of many species must take great precautions if they are to fly away and breed elsewhere another day. Discretion would seem to be the better part of valor in such cases, and a closer look may further debunk our notions of the macho male. Because mating is an intimate process, it can be very dangerous, particularly if the female is large and an efficient predator. As a result, indirect sperm transfer mechanisms have evolved in many animals. Spiders, for instance, store sperm in special organs called pedipalps which are situated on the front of the body. The sperm are produced in the abdomen, passed onto a silk square called a sperm web and then picked up by the pedipalps. Each pedipalp is a little like an old-fashioned fountain pen with a reservoir and point. The sperm are stored in the bulb-like reservoir and passed into the female through the "point," which is called an embolus. By conducting the operation at arm's length, the risk of mating with a fierce predator is probably minimized. Scorpions carry this idea a step further. Males secrete a sperm-filled structure called a spermatophore, which stands on the ground. Females are inseminated through contact with the spermatophore. In some species, this is analagous to a hypodermic syringe with a needle and plunger. During courtship the male grasps the female, pincer to pincer, and leads her over the spermatophore. When the female's sex opening engages the "needle," pressure expels the sperm and insemination occurs.

Adaptations to minimize the risks of intimacy may be behavioral as well as structural. For example, one species of praying mantis exploits a narrow window of opportunity, mating in the 20 minutes between first light and actual dawn. "This is the only time of day that the mantis can assume the conspicuous position required without placing himself at great risk from predatory birds," Robinson explained. So why not play it safe by mating after dark? Because the risk posed by a female mantis, who does not seem to care for surprises, might be as great as that posed by a

A tiny male wood spider mates with a huge, potentially dangerous female (left). (Photo by Michael Robinson.)

The new Invertebrate Exhibit offers several intriguing examples of complex adaptations for reproduction. For example, only one female leaf-cutter ant in NZP's colony is able to reproduce—the others, numbering in the thousands, are sterile. (Photo by Jessie Cohen, NZP Graphics.)

predatory bird. If you are a male mantis, you either approach the female from the proper end, or quite literally lose your head. Thus the male faces a double-threat—he must avoid becoming a bird's breakfast, yet have enough light to see the right way to approach his mate. But even decapitated, in some species the male is "hard-wired" to copulate before he dies, said Robinson.

Throughout the animal kingdom, "the price of masculine hormones is high," Robinson continued. Males risk life and limb to win rights to females—the vehicles that allow their genes to be passed on. In fact, this male-male battle of wits and strength, involving such tactics as deception and display as well as outright dominance, is "a driving force in the evolutionary process," Robinson said.

One might think that perhaps the price is *too* high. Wouldn't it be simpler for all animals just to bud like hydras, reproducing themselves without resorting to the rat race? But this brings us to the very point of sexual reproduction which, for all its apparent costs, has the great benefit of allowing new characteristics to arise through the recombination of genetic material. This is what allows species to adapt to changing conditions, albeit very slowly, over time and many generations. It also has a decided short term advantage: "Varying the genetic make-up of offspring is a way of not putting all one's eggs in one basket," Robinson added.

If external environmental conditions vary, sexual reproduction is the best strategy. If conditions stay the same for endless generations, asexual forms of reproduction (such as budding or fission) may be best, since an animal that is already successful in a constant environment might not need genetic diversity in its offspring. Thus cloning capitalizes on success but cannot cope with change.

But wait a minute, you may be saying, this adaptation business is all very well for a sloth in the jungle, but how can I, with my climate-controlled house and fully stocked supermarket and my choice of 100 satellite TV channels, possibly need to adapt genetically to changing conditions?

Indeed, those of us who can afford it have the maintenance of our stable, small-scale environments down to an art. Does that not somehow place us closer to the budding hydra in its com-

fortable pool than it does to the animal on a new frontier? In other words, do we still "need" sex? In fact, to be blunt, do we still "need" males at all?

As humans made the switch from biological to social evolution, the importance of genetic variability diminished. We adapted our surroundings to combat changes in the environment and the complex process of technical innovation actually eliminated the need for physical evolution through biological adaptation. Or so it would seem. Because our bodies do not need to adapt, because the weak often survive as well as the stronger, we have outgrown the value of sex as a means of producing evolutionarily important variability. Or have we?

"We humans could be at a stage in our history where sexually generated genetic variability is irrelevant to our survival," noted Robinson. "Except for one thing: Our battle with disease." Despite advances in medicine, disease kills and therefore selects. Recent work by biological theorist W.D. Hamilton has highlighted this aspect of human fallibility, suggesting that the fundamental value of variability lies in our disease-fighting defenses. "If all humans had the same system for recognizing invading cells, one mutation in a bacterium, virus, or parasitic protozoan could make it undetectable by our defenses," said Robinson. "The mutant form would then become the 'stealth bomber' of our interior territories." This does not happen because our immune systems are genetically determined, and thanks to sexual reproduction, our identifying cellular "fingerprints" are all different. (In fact, no two people are alike in this respect, with the exception of identical twins; this is the reason why the immune system must be "knocked out" during organ transplantation and also explains why cross skin-grafting does not work.) Thus genetic variability keeps us slightly ahead of the infective organisms that reproduce through millions of generations in one human lifetime.

Perhaps dismayed at the humble form and role of their counterparts in much of the "lower" animal kingdom, male readers may nonetheless take comfort in the knowledge that in the eyes of the females of their species, they are still loved and needed, if not to fend off toothed and clawed invaders, then at least to beat back a fierce wave of bacteria. □

Cuttlefish (below) die off synchronously after mating; the sudden disappearance of adults could make cuttlefish an unpredictable resource for predators.

Jessie Cohen, NZP Graphics

ZOOlab Redux

Judith White

This school year ZOOlab celebrates two birthdays: It is 10 years old and newborn at the same time. Located in the National Zoo's Education Building, ZOOlab underwent a complete renovation last summer and now boasts an exciting new look with learning materials and activities to match.

Visitors entering the lab find themselves face-to-face with colorful animal cut-outs—an elephant, a bear, a tortoise, and a toucan pair—mounted atop square exhibit modules. Surrounding each cut-out is an assortment of related objects; for example, the "Elephant" module features a tusk, a large bone, an enormous tooth, jars of hay and other foodstuffs, and a piece of cloth that shows the approximate size and shape of an elephant's ear. Asking "Which side of the tooth grinds food?" and "What part of the elephant does this bone come from?" question cards invite curiosity, comparison, and careful touching of the objects displayed.

Adults may need to stoop a bit but the exhibit modules were purposely built low to encourage children to peer, poke, and investigate. Because NZP's other learning labs—HERPlab and BIRDlab—are intended for older visitors, the new ZOOlab has been redesigned with a younger audience, primarily four- to eight-year-olds accompanied by parents, in mind.

Wall displays invite further participation. An exhibit labeled "KEEPERS" shows life-sized photos of Zoo staff and displays assorted tools of the keeper trade, including a snake hook, a bird net, a broom, boots, and a uniform shirt. Lab visitors are encouraged to "dress up" and try their hand at various tasks, such as using a mirror attached to a long pole to peer into a bird's nest on a high shelf. Like a veteran Bird House keeper, the skillful visitor may discover eggs inside!

A parade of life-sized animal silhouettes marches along a wall labeled "SIZES." Here, a measuring stick painted on the wall invites children to contrast their own sizes and shapes with those of an ostrich, a lion, a gorilla, and other animals.

A third wall, marked "COVERINGS," offers visitors the chance to touch and compare the skins of various mammals, reptiles, and birds.

Finally, as in the original ZOOlab, an assortment of learning boxes may be borrowed from the check-out counter and examined in detail while sitting at a table. "Match a Feather" and a few other popular boxes are back and several new titles, including "No Bones" and "Footprints," have been added; however, box contents have been completely re-designed so that they are appropriate for parents and young children to use together. Moreover the new box designs incorporate a number of interpretive approaches that have been successfully developed over the years in other learning labs. Featuring the best of the old and the new, the renovation of ZOOlab seems a fitting celebration of a decade of learning labs at the National Zoo—a decade that began with an innovative experiment—ZOOlab.

The establishment of ZOOlab came about as a natural extension of work on the Smithsonian Museum of Natural History's Discovery Room, an educational, "please touch" collection of fossils, shells, skins, and rocks which project initiator Caryl Marsh and I assembled in 1974. Surely zoo visitors would also enjoy opportunities for hands-on learning which might enable them to view the live animal collections with more knowledgeable and appreciative eyes.

When the Zoo's Education Building opened in 1977, a room became available and at last it was possible to try out the Discovery Room idea. Animal objects that we had been collecting for years were quickly gathered, learning boxes were furiously assembled, furniture was ordered, and ZOOlab was opened within six short months. The experiment was launched! Staffed by FONZ volunteers, ZOOlab proved to be an immediate hit with both visitors and colleagues, and in 1978, the American Association of Zoological Parks and Aquariums (AAZPA) awarded the National Zoo its Education Award for ZOOlab.

The success of ZOOlab led to the creation of a second, smaller learning lab later the same year. Carved out of a hallway in the Bird House, BIRDlab is small (it holds 15 people comfortably), but any disadvantage is outweighed by its location in the midst of the living collection of birds.

Several years later, the Reptile House was renovated and space was included for a learning center. The Education staff was overjoyed—here was a chance to develop a full-scale learning lab that would directly support and interpret the living collection in the building. Titled HERPlab, it would arouse visitors' curiosity about the animals and provide learning materials for in-depth study of reptiles and amphibians. A grant from the National Science Foundation (NSF) took HERPlab from concept to reality, while the funds and time line NSF encouraged allowed us to develop the lab more thoughtfully than had been possible in the past.

The new project was specifically geared to families—a logical choice, but a stiff challenge nonetheless as learning materials and activities had to be developed at a variety of levels to accommodate the different ages and interests within a family group.

Evaluation and audience involvement were key to the refinement of HERPlab learning materials. Visitors' ideas and responses to various activi-

ties were solicited during the first phase of design, and learning box prototypes were tested with families before the lab opened. NSF was eager that the HERPlab project provide a model for other zoos and aquariums, so two other zoos were invited to try out the materials. Using copies of the prototype learning boxes, the John Ball Zoo in Grand Rapids, Michigan, and the Philadelphia Zoo set up mini-HERPlabs. An extensive evaluation by visitors was then conducted at all three sites. How would HERPlab materials fare at other zoos? Could the program truly serve as a model? It was heartening indeed to discover that the responses of both Grand Rapids and Philadelphia visitors were very similar to those of visitors at the National Zoo.

So, from an experiment called ZOOlab to a three-year NSF development project to the new ZOOlab, what have we learned? What is the importance of the labs?

First, the labs have great holding power. A recent study of almost 600 National Zoo visitors by NZP Reptile Curator Dale Marcellini and visiting scientist Thomas Jenssen showed that the average length of a visit to the Reptile House is 15 minutes—8 minutes of which is spent walking from one exhibit window to the next. A preliminary study of the Small Mammal House revealed similar findings. In contrast, during our formal evaluation of the HERPlab project, Education Specialist Sharon Barry and I found that the average amount of time spent in HERPlab is 30 minutes. Visitors come in, sit down, and *stay*.

Visitors also return to the labs. A FONZ HERPlab Volunteer has dubbed one group "be-backers." They tell her "We'll be back"—and they are. In ZOOlab as well, volunteers see the same families over and over again.

Just why do visitors value their visits to a lab? "You discover things you wouldn't ordinarily learn on a stroll through the Zoo," said one visitor. On the whole, comments reveal visitors' surprise that learning and having fun are not mutually exclusive activities . . . which comes as no surprise to Zoo staff, who designed the learning boxes to be fun as well as to convey new information and concepts.

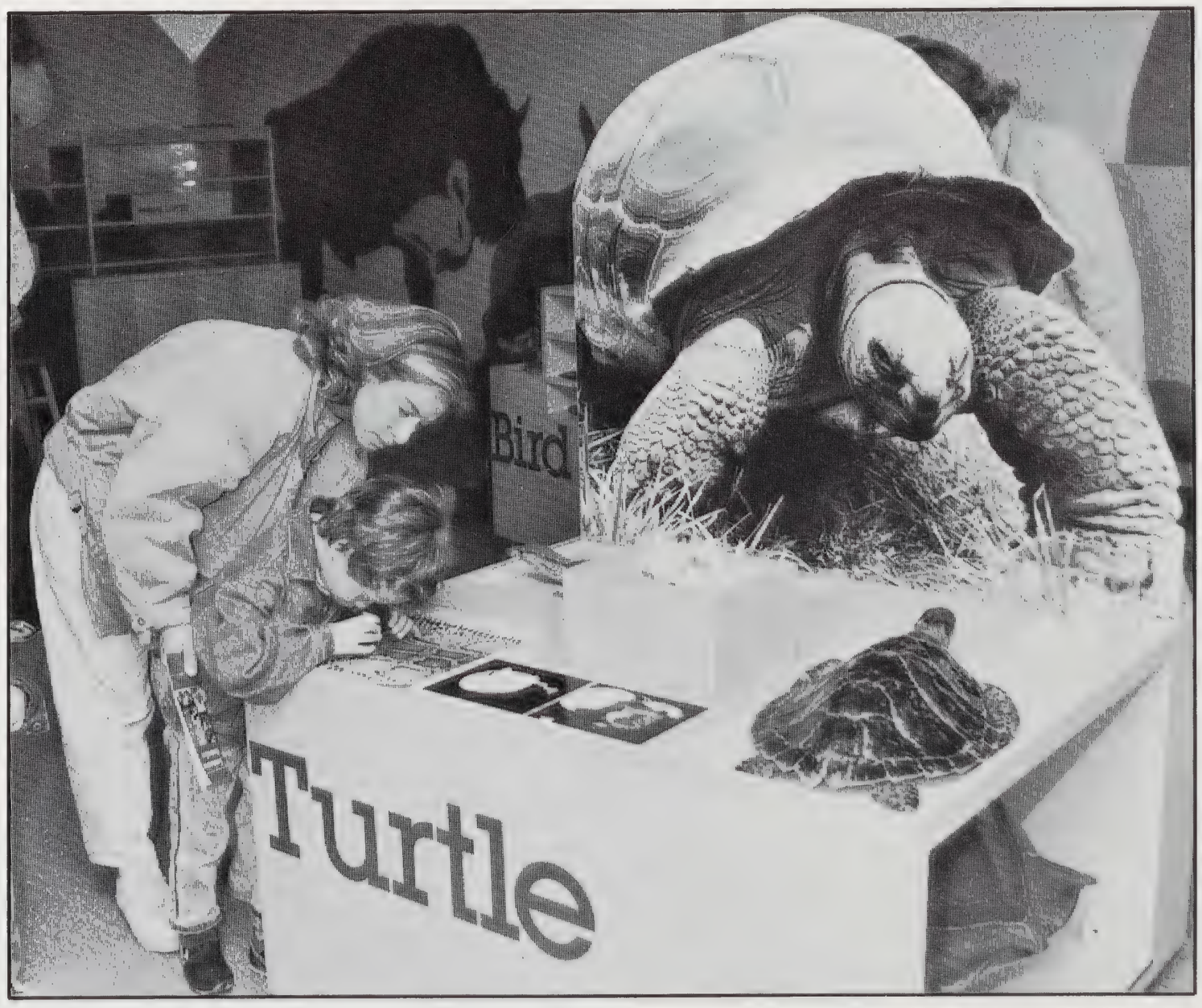
In the labs, visitors read, explore, and learn at their own pace. The opportunity to become actively involved—to *do* things—is also important. Putting bones together, playing games, or matching questions and answers all require active involvement. With access limited to a manageable number, the protected environment of the lab allows visitors to get closer to objects and animals than is possible in the open grounds of the Zoo. Visitors value the chance to come nose-to-nose with a frog in HERPlab or to touch real animal bones, fur, or feathers. Through these close encounters they can make real contact with the living world—which is an unusual opportunity in a zoo or museum where the precious collection must be kept out of reach.

For museum educators anxious to know more about zoo audiences, the lab is an ideal place to learn about and chat with family visitors. Many are eager to let you know what interests them or to suggest new ideas for zoo exhibits. Moreover, the labs have built-in flexibility: Unlike the large, sturdy signs and exhibits in the Zoo, the labs' materials are produced in-house with simple techniques and can therefore be revised and fine-tuned to fit visitors' changing needs and interests.

Finally, the labs have spawned countless new ideas. Teachers' interest in the labs' materials recently gave rise to an outreach program: Kits about mammals, reptiles, and birds now travel to local elementary schools to help teachers and children learn about animals. Objects and activities that originated in the labs are now in the hands of the FONZ roving guides, provoking curiosity and questions throughout the Zoo. Colleagues around the world—in Egypt, India, Australia, and Great Britain—have picked up our lab ideas and are creating their own versions. An urban nature center in India borrowed the FROG and SNAKE animal observation cards developed for HERPlab and sent us back their own versions—COCKROACH and MOUSE. Most recently, Australian zoo educators studied the labs and applied their findings to the development of "Habitat Hall: A Conservation Lab" at the Melbourne Zoo. Perhaps in the future the National Zoo will borrow back ideas to further enrich our own labs, bringing the exchange full circle.

Ever changing and evolving, the labs' flexibility is perhaps their greatest strength. It is with this in mind that we celebrate the re-opening of ZOOlab: a ten-year old newborn! □

Judith White is the Head of the NZP's Office of Education.



Jessie Cohen, NZP Graphics

Jessie Cohen

Raccoon

Backyard Safari

A habitat is an area in which animals find the food, water, and shelter they need to survive. At the Zoo, you can see animals from exotic habitats like jungles or coral reefs. But many kinds of habitats exist near your home as well—woods, fields, streams, and even Washington's city streets are home to different wildlife communities.

A forest is filled with the signs and sounds of many hidden animals. For example, messy clumps of dead leaves in the treetops may be the nests of squirrels, while tree holes often serve as nesting places for woodpeckers, chickadees, and other birds. These creatures find shelter in the trees, beyond the reach of predators like cats or foxes. Owls, which hunt by night, may also hide in tree holes or pine trees during the day. Sometimes crows "mob" the owls, chasing them away from their hiding places. Sounds, like the chirp of a chipmunk or the flutelike song of a wood thrush, are also clues that unseen animals are nearby.

On the ground in the forest you may see a box turtle feeding on mushrooms. Unlike many other turtles, which swim for their supper, box turtles prefer to eat mushrooms, earthworms, and berries. If you find open spaces in the forest where a tree has fallen, look out for striped lizards the length of your hand. These lizards are called skinks. Skinks lie in the sun like sunbathers, but they're not trying to get a tan. Like other reptiles, skinks absorb the sun's heat, which keeps their body temperatures up and gives them energy. Skinks hunt insects that live in fallen, rotting logs.

A stream is always worth a closer look. Many animals come to streams to drink and feed. You may see small, hand-like tracks left by a raccoon, or a harmless brown-banded water snake swimming toward the shadows. Look for schools of small minnows streaking by beneath the water, or spider-like water striders scooting across the water's surface. By lifting up small rocks in the water, you may discover salamanders, small, lobster-like crayfish, or perhaps a striped minnow. These animals are hiding from the large birds, fish, and raccoons that hunt them. Be sure to replace the rock so the animals can find the hiding place again.

Cities are also home to some kinds of wildlife. Pigeons, shiny starlings, and black-bibbed English sparrows share downtown streets with city squirrels. Urban creatures may find food in trees people have planted, and even in trash. In Washington and some other cities, sea gulls circle overhead and often gather by the hundreds to feed at trash dumps. Remember that even in a city, wildlife is still wild—

Pull out

Jessie Cohen

Gnawed tree trunks are a sign that beavers live nearby.

do not try to pet or catch these animals.

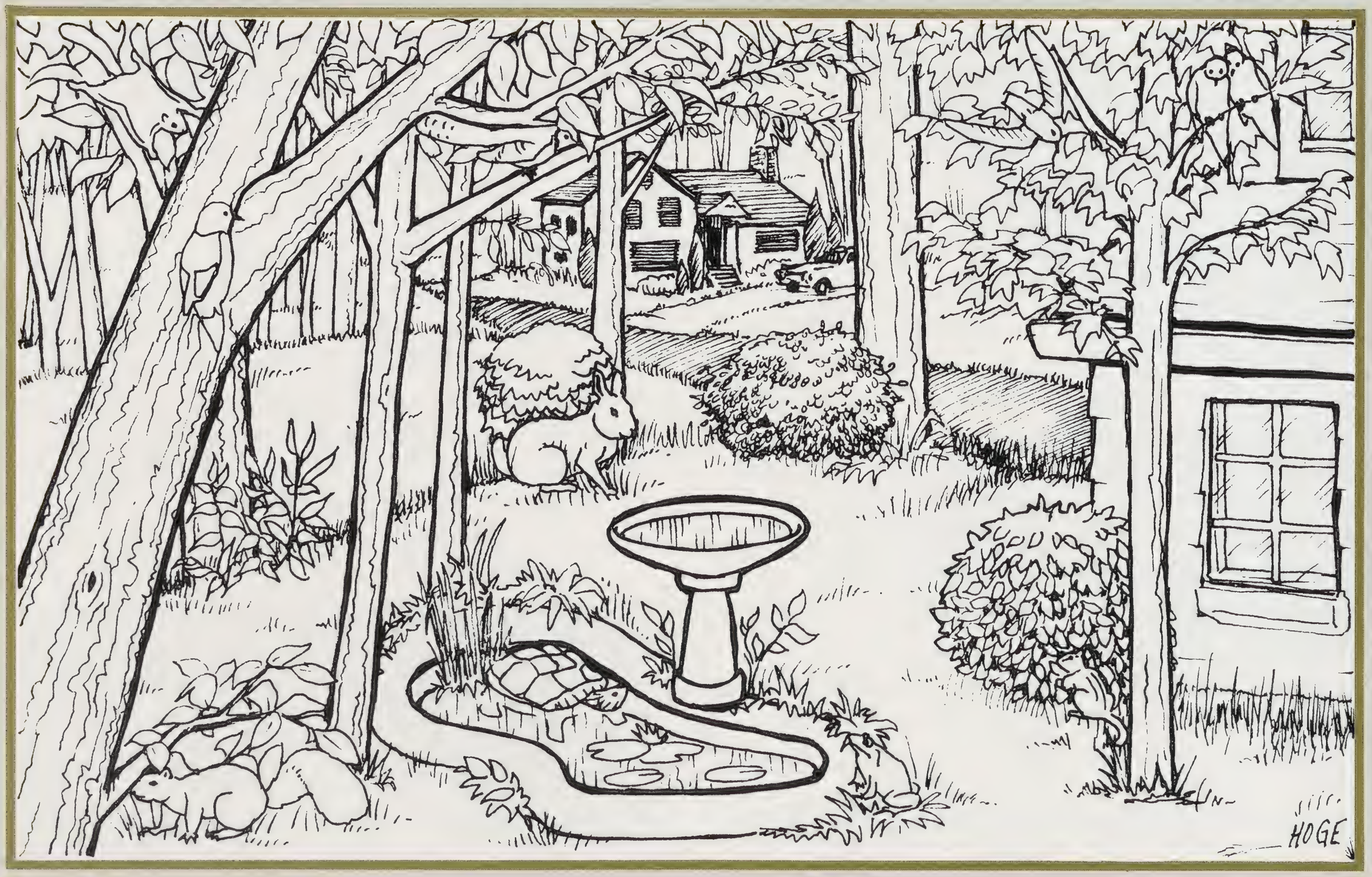
Keep your eyes open when riding in the car. Grassy and wooded areas along highways are good places to see wildlife. Look for the silhouettes of hawks high in the trees, or a chubby groundhog in the grass. Graceful, fork-tailed swallows may swoop by in search of insects; these birds often nest under bridges and highway overpasses.

Large animals may also be closer than you think. White-tailed deer, turkeys, and bald eagles, for example, can be seen in patches of field and forest in the Washington area. Foxes even live in Rock Creek Park.

Putting up nesting boxes and bird feeders, or planting bushes and trees will help birds and other animals find the food and shelter they need. The more you learn about the wildlife near your home, the more successful your efforts will be. These books may help you get started with your wildlife adventures: *My First Insects: A Pop-up Field Guide* by Cecilia Fitzsimmons (Harper & Row); *Naturewatch* by Adrienne Katz (Addison-Wesley); and *America's Favorite Backyard Wildlife* by Kit and George Harrison (Simon & Schuster).

—*Howard Youth*

Christopher Hoge

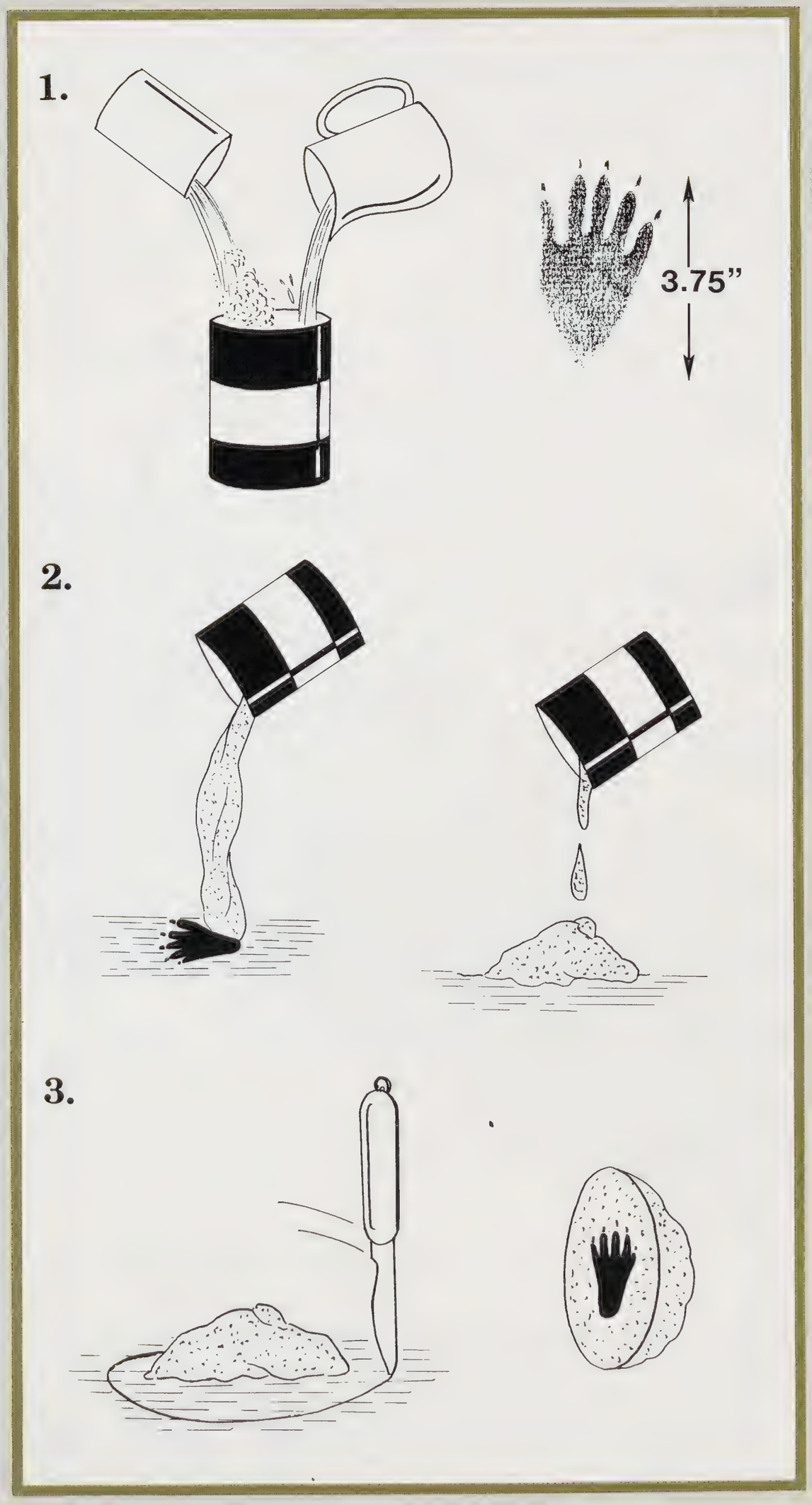


A CLOSER LOOK

It is often easy to overlook wildlife around your home. Can you find and identify the ten wildlife species in this backyard? (Solution on p. 18)

Making Tracks

by Sriyanie Miththapala



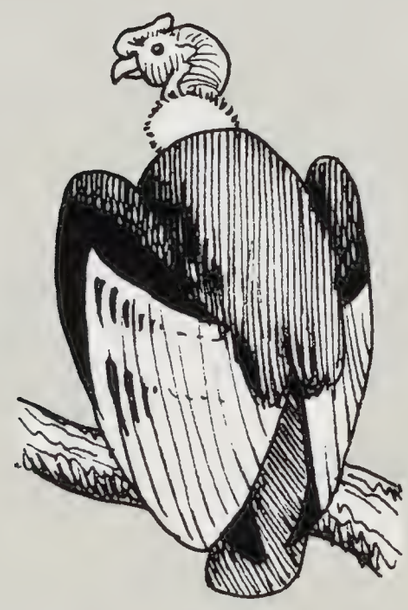
While hiking through the woods, you may discover pawprints along the trail. To save an animal track, like the hind footprint left by this raccoon, follow these simple steps:

1. In a tin can, mix plaster of paris and water to make a thin batter.
2. Carefully pour the mixture into the track, allowing it to overflow. Leave the plaster to harden for between 10 and 30 minutes.
3. Once the cast has hardened completely, cut around it and lift the piece of ground up from underneath. Brush off the dirt and take your plaster track home.

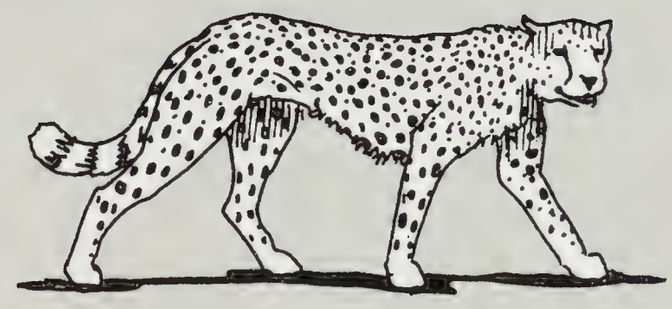
HABITAT MATCH

Can you match each of the exotic animals below with the description of its habitat?

Bongo ____
(Tragelaphus euryceros)

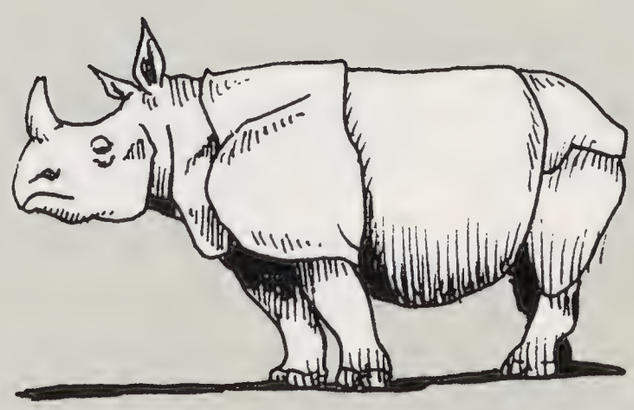


Andean condor ____
(Vultur gryphus)

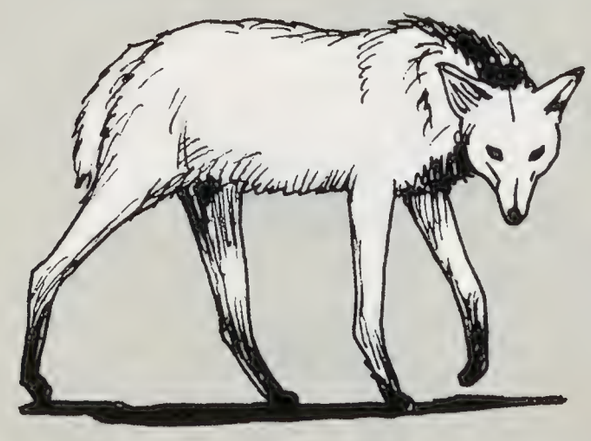


Cheetah ____
(Acinonyx jubatus)

Giant panda ____
(Ailuropoda melanoleuca)



Greater one-horned rhino ____
(Rhinoceros unicornis)



Maned wolf ____
(Chrysocyon brachyurus)

1. This large, striped vegetarian browses leaves and shoots deep in the lowland tropical forest of central Africa.
2. Small animals and plants make up the diet of this golden-furred mammal from the tall grass plains and scrub forest of central South America.
3. The bamboo forests of mountainous western China are home to this rare, two-colored carnivore.
4. Swampy, tall grass plains in northwestern India and Nepal offer the food and moisture this thick-skinned giant needs.
5. The rugged, rocky mountains along the length of South America's west coast contain the wind currents this huge scavenger uses for soaring.
6. This slim hunter sprints after prey on grassy, tree-dotted plains in the drier parts of Africa.

A Closer Look Solution: squirrel, blue jay, painted turtle, bull frog, chipmunk, cottontail rabbit, mourning doves, chimney swift, woodpecker, and flying squirrel. **Habitat Match** Solution: 1. Bongo 2. Maned wolf 3. Giant panda 4. Greater one-horned rhino 5. Andean condor 6. Cheetah.

Life of a Tigress

John Seidensticker

Fiona Sunquist

Chuchchi

Charles McDougal, a National Zoo Research Associate, has been watching the tigers of Nepal's Royal Chitwan National Park for more than 15 years. His long-term observations are the most extensive ever made on tiger behavior and ecology. Over the years, as he tracked the rich details of their lives, Chuck also came to know many individual tigers intimately. He recently wrote to report the death of a tiger and a friend.

"On the afternoon of August 10, 1987, the still-warm remains of female tiger No. 115, 'Chuchchi,' were found beside the path between Dhaker Khola and Banth Khola Puchchar, just south of the Reu River in Chitwan. Her back was broken. A careful reading of tracks showed she was killed by a forepaw blow from a 3-year old male tiger, the son of female tiger No. 122. At the time of her death, Chuchchi was emaciated (98 kg or 215 pounds) and had badly worn canines. She was at least 15.5 years old."

From the time Chuck started watching tigers, Chuchchi (meaning "pointed toes," for her distinctive tracks) had been an unobtrusive and vital force in Chitwan, where she lived and hunted and reared her cubs in the tall grass and riverine forest on the flood plain between the Rapti and Reu rivers. She was a key figure in the scientific monographs and papers on tiger social organization and land-tenure system written by Chuck and by former Smithsonian Tiger Ecology Project scientists Mel Sunquist and Dave Smith.

I first met Chuchchi in 1974 when she was still working out the boundaries of her territory with No. 122's mother. When Chuck and I studied tiger predatory behavior, Chuchchi was one of our focal animals. She was also an important player in our study of interactions between tigers and leopards. We learned that female tigers defend territories from other females by watching and tracking Chuchchi and her neighbors. Chuck and Dave Smith learned how female tigers maintain exclusive territories without fighting by observing Chuchchi and female tiger No. 122 mark and inspect trees along their common boundary. Through radiotracking (she was first collared in 1978), careful reading of pug marks, and direct observation, Chuck and his Shikari assistants learned the details of Chuchchi's life.

Although Chuchchi lived on the same territory throughout her breeding life, in 15 years she had many different males in her life. The first male to occupy a territory that overlapped Chuchchi's was No. 102, in 1975-76. From 1976 to November of 1979 there was No. 105, followed by Sahila Bhale, whose tenure lasted until August of 1981. Then there was a 6-month period of upheaval. First to enter the vacant territory was a young male, No. 123, but he was soon joined by male No. 127. In the ensuing fight over possession No. 123 was killed. No. 127 was usurped in February of 1982 by Kanchha Bhale, who took over and stayed until 1985. He was then replaced by Bahadur Bhale, the last of Chuchchi's males. Some of these male tigers fathered her cubs; some probably killed her cubs; some undoubtedly did both.

Chuchchi's first litter was born in mid-1975, her last in mid-1985. In those 10 years she produced a total of 16 known cubs in five litters. Eight cubs survived at least until they dispersed at about two years of age, but Chuck doesn't think any of the cubs in her last litter survived.

Adult female tigers often remain near their mothers and some even acquire territories from their mothers. A female from Chuchchi's 1977 litter, known as the Panch Pandu Tigress, settled adjacent to her mother in 1979. In 1981-82, Chuchchi gave up about half of her territory to her daughter Jabarjastri, who was born in 1979. Kanchhi Pothi, a daughter born in 1982, never left her mother's territory. In fact, she finally drove Chuchchi out at the end of 1986 before she produced her first two cubs in May of 1987.

In the last few months of her life, after Kanchhi Pothi displaced her, Chuchchi took a number of long, wandering trips to places she was never known to have visited before. But she kept returning to the Dhakre Khola area, where she had spent her life and where she finally met her death.

In his book, *The Face of the Tiger*, Chuck described an encounter with Chuchchi—a face-to-face meeting on a knife-edged Swilalik ridge: "As I crested a rise on the ridge I saw a rapid movement and a flash of reddish-brown just on the near side of the next rise. It suddenly resolved itself into the tigress, who crouched facing me 15 yards away, her eyes locked into mine. I did not move. She did not move . . . . Then it struck me that perhaps the tigress was leaving the first move up to me. Quite slowly, so as not to alarm her, I took a step backward. Then, as there was a sheer drop on either side, I turned around and retraced my steps back along the ridge the way I had come, resisting the impulse to look over my shoulder."

Sound conservation practice and policy is based on good natural history. The glimpses we had into Chuchchi's life were essential to our comprehensive understanding of tiger ecology and behavior. You could say she is the "stuff" of what we know about tigers. This information is the foundation of the enormous conservation effort mounted by His Majesty's Government of Nepal, which makes it possible for Chuchchi's daughters and granddaughters to still stalk their prey and raise their cubs in the tall grass of Chitwan Valley. But Chuchchi is gone. All of us who knew her feel a great loss. □

Sloths: Slowly but Surely

Fiona Sunquist

A three-toed sloth in a Cecropia *tree. (Photo by John Hoke.)*

Sloths have long been the subject of ridicule. In 1802, French naturalist George Buffon dismissed sloths as "defective monsters" and concluded that "the inertia of this animal is . . . the consequence of its faulty structure." Sloths, in short, were considered one of nature's mistakes—and named accordingly for one of the seven deadly sins. But it now appears that sloths have been slandered.

Thanks to a study initiated by National Zoo scientists in the early 1970s, our misconceptions about these enigmatic creatures have finally been dispelled. Sloths are in fact superbly adapted, highly specialized tree-dwellers and offer an amazing example of energy conservation in the animal world. Slowness is just one of many sloth specializations, but it may well prove to be these species' key to success.

Although we are accustomed to thinking of "the" sloth, five species, representing two separate families, actually exist. The two- and three-toed branches of the sloth family tree separated some 15 to 20 million years ago, yet the differences between them are not readily apparent—except presumably to other sloths. Both two- and three-toed sloths live in the canopy of Central and South American forests, ranging from southern Mexico through Venezuela and Brazil to northern Argentina. Two-toed sloths are larger, weighing about 15 pounds, whereas their three-toed "cousins" weigh only about eight or nine pounds. The distinctions between individual species are finer yet.

Fine distinctions may be lost on most zoogoers, however, for two-toed sloths are the only type they are ever likely to see. The National Zoo has exhibited sloths since the 1950s, and the initiated easily identify as a sloth what looks like a shaggy, slightly moldy old rug hanging from the branch of a tree in the Small Mammal House. Two-toed sloths do well in zoos, thriving and reproducing on a diet of apples, carrots, sweet potatoes, and monkey chow. Indeed, some individuals have lived more than 30 years in captivity. The zoo longevity of three-toed sloths, on the other hand, is usually measured in weeks rather than years. Indeed, most zoos no longer even try to exhibit them because the animals always die of starvation—even when their stomachs are full.

The few early attempts to house three-toed sloths ended sadly, yet the reasons for these failures gave rise to a wide-ranging scientific investigation. Clearly the problem involved the animals' nutritional requirements, but no one could pinpoint which vital ingredient was missing from their zoo diet. After all, it was common knowledge—or at least widely believed by amateur and professional naturalists alike—that all sloths lived in *Cecropia,* a common neotropical tree of forest openings, and ate only the leaves of that tree. Or did they? In 1970, John Eisenberg, then head of NZP's Department of Zoological Research, decided that a field study of sloths might resolve the question—and possibly provide clues that would make it possible to keep three-toed sloths alive in the Zoo. He recruited Gene Montgomery and Mel Sunquist to carry out the field work on the Smithsonian Tropical Research Institute's Barro Colorado Island in Panama. For the first time, sloths were subjected to intense scientific scrutiny.

Montgomery and Sunquist climbed one tree after another, hacking their way up into the vine-tangled canopy in search of sloths. They put radio collars on more than 50 sloths and began to record their movements. Before long, a surprisingly simple explanation for the centuries-old story of sloths feeding only in *Cecropia* trees became clear.

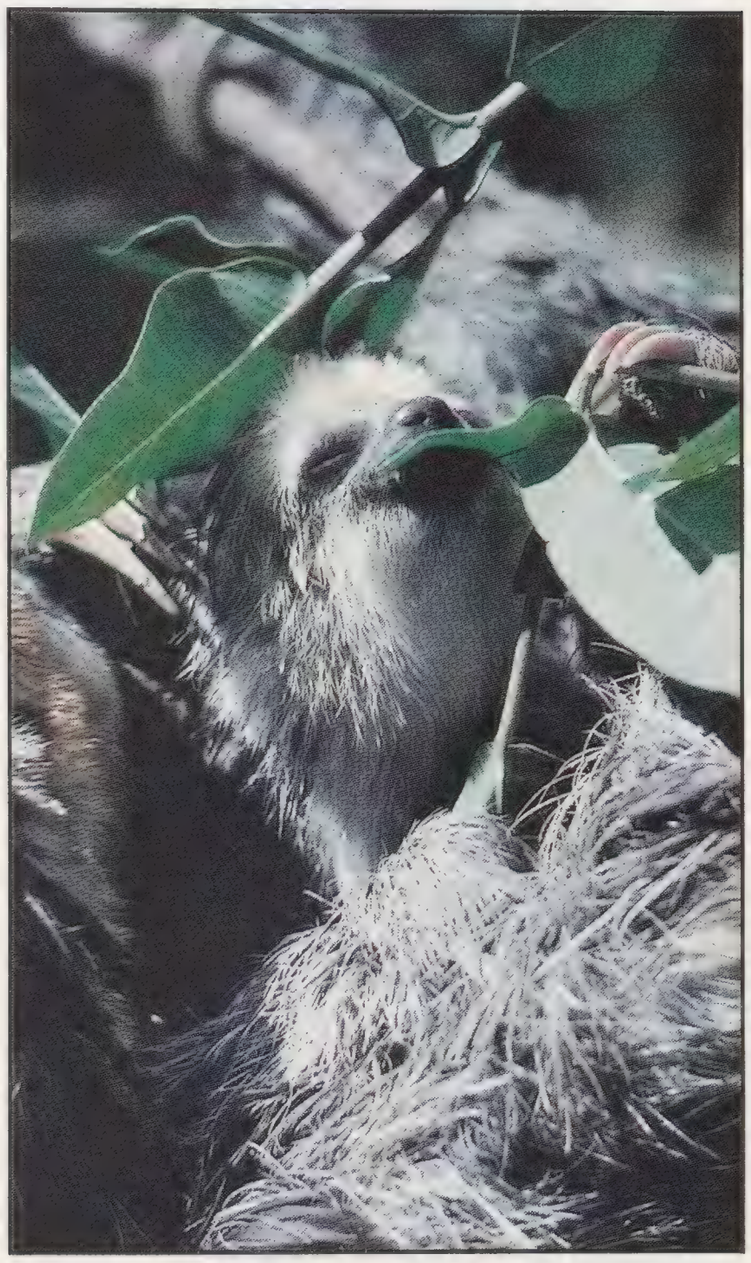
The *Cecropia* tree has large leaves that grow in well-spaced clusters near the tips of branches; thus it is easier to see a sloth in a *Cecropia* than in any other tree. But this does not mean that the animal does not inhabit other trees. The two biologists discovered that sloths use at least 96 different species of trees and vines, but the dense forest growth usually conceals the sloths, rendering them invisible to the casual observer.

The three-toed sloth's dietary preferences offered the next surprise. Each species of sloth eats leaves, which are, of course, the most abundant food source in a forest. But whereas *Choloepus hoffmanni,* the two-toed species studied in Panama, is fairly catholic in its tastes, eating a variety of fruits and flowers as well as leaves, *Bradypus variegatus,* the three-toed species studied, is a highly specialized leaf-eater—and therein lies the problem of keeping the three-toed species in zoos.

Leaves are not easy to live on. They tend to be low in protein, difficult to digest, and yield little energy. Some leaves even contain toxins that discourage leaf-eating animals. Little surprise then that few animals feed solely on leaves; those that do must make certain compromises to earn their meal ticket. For example, a leaf-eating species' behavior must be

Fiona Sunquist is a wildlife writer and photographer. With Mel Sunquist, she is the author of the forthcoming book Tiger Moon.

John Hoke



Three-toed sloths conserve energy by hanging upside down.

adapted to conserve energy and its digestive system modified to cope with the difficult diet. Koalas, hooked on eucalyptus leaves, have evolved these traits; so have the leaf-eating langurs. But the three-toed sloth is a supreme example of such adaptation.

Almost everything about a sloth is designed to allow the animal to expend as little energy as possible. Essentially, the animal is little more than skin, bones, and stomach. It has about half the amount of muscle of any similarly sized animal, which reduces energy expenditure because it takes energy to maintain muscle. The sloth's peculiar, upside-down form of locomotion requires fewer muscles than the complex balancing act performed by other aboreal mammals such as monkeys; by hanging rather than standing, the sloth conserves energy.

Most mammals use a great deal of energy keeping their body temperatures nearly constant throughout the day and night. The sloth saves energy by allowing its body temperature to drop at night, sometimes by as much as seven degrees Celsius (12 degrees Fahrenheit). The body temperatures of other mammals also vary a bit over the course of a day and night, but not nearly so much—a drop of 7 degrees Celsius would normally occur only if a mammal was in hibernation. In the morning, the three-toed sloth climbs to the uppermost branches and basks in the sun, using the free solar heat to get its body temperature back to normal.

Running away from predators can use up a lot of energy, so the sloth relies on a camouflage coat and keeping still, rather than trying to escape. Sloth hair is unlike the hair of any other mammal. The spongy hairs absorb water and algae grow in cracks along the length of the hair shaft. The algae give the sloth a greenish tinge and, thus camouflaged, the animal becomes almost invisible when it sleeps folded up in the crotch of a tree.

Swimming can be an energetic activity but—true to form—when the sloth swims it is with very little effort. Sloths often take to the water to reach other feeding sites; sometimes they use a gentle swimming motion, but generally they float. With no heavy mass of muscle to weigh it down, a sloth's buoyant, oversized stomach acts like a beach ball to keep it afloat.

A full stomach may account for as much as a third of a sloth's body weight. It functions as a fermentation chamber, in which bacteria break down the leaves to release energy-containing products that can be absorbed by the sloth's gut. Not unexpectedly, digestion takes a very long time—up to twelve days (compared with about one day in humans). In fact, the sloth's rate of digestion is the slowest recorded for any mammal. Even when feeding, a sloth expends the least possible amount of energy: It hangs from a branch and swings its head around without moving the rest of its body. A flexible neck, comprised of more vertebrae than the necks of all other mammals, enables the sloth to do this.

The most surprising thing that Montgomery and Sunquist found was that each individual sloth has its own feeding pattern which seems to be handed down through the generations, with young learning from their mothers which trees and vines to live in. The mothers may also pass on to their offspring the specialized gut microorganisms that help them digest the leaves of these particular trees. This, the two biologists realized, explained

John Hoke

A female three-toed sloth carries her young for six months, allowing it to learn the mother's specific diet and to ingest samples of her gut microflora from shared food.

why sloths manage to live at far greater densities than do other animals. In fact, in some places, sloths make up more than 70 percent of the arboreal biomass—the combined weight of all the individual animals in a given area. Each female sloth has her own unique repertoire of some 40 tree species in which to live and feed; because they don't compete with each other for the same food resources, many sloths can live in close proximity.

A female three-toed sloth gives birth to a single offspring each year. She nurses it for only about six weeks but continues to carry the baby on her chest for six months. When it is just two weeks old, the young sloth starts licking fragments of leaves from its mother's lips, then quickly graduates to eating whatever it can reach without letting go of its mother. Thus, while being carried around the tree canopy, the young sloth "inherits" its mother's eating patterns—and also, by licking her face and mouth, ingests samples of her special mix of gut microflora, specific to her repertoire of leaves.

When the young sloth is about six months old, the mother abruptly moves to another part of her home range, leaving the offspring behind. The young sloth then has a chance to test its independence in a familiar area, while the mother uses another set of trees nearby. Six months later the mother returns, having given birth to a new baby, and the one-year-old moves on to a new area, taking with it a learned list of tree species from which to feed. If it is a female, the young sloth will pass this information on to the next generation.

This is the reason why you'll probably never see a three-toed sloth in captivity. Each sloth is confined to its particular list of trees by its gut microflora and is physically unable to digest anything other than leaves from those particular trees. A zoo could not possibly know which tree species' leaves were acceptable to an individual sloth and which were not—let alone try to obtain those leaves. To develop a zoo diet and adapt sloths to it, while not impossible, would require extensive research and testing. But the fact that the three-toed sloth does not live in zoos does not make it one of nature's mistakes. On the contrary, it should be seen as another one of nature's greatest successes. □

Jessie Cohen, NZP Graphics

Two-Toed Sloths

In 1950, the National Zoo obtained its first two-toed sloths. Unlike their three-toed cousins, two-toed sloths usually thrive in zoos and those housed at NZP have proved no exception. After 37 years, sloths are still being exhibited in the Small Mammal House.

In the wild, these sloths of Central and South America are nocturnal and solitary. Sleeping by day, two-toed sloths spend their nights climbing through trees and vines in search of the leaves, twigs, and seasonal fruits they eat. Their apparent preference for sleeping in lianas may be an adaptation against predation as the woody vines will shake under the weight of a large animal, alerting the sloth to danger.

The National Zoo's sloths lead a somewhat different lifestyle. Despite the fact that these animals are solitary in the wild, the three at the Zoo live together without a problem. Encounters between sloths are rare except during mating. However, sloths do not defend their trees and occasionally two conspecifics will be found in the same tree, just as they are at the Zoo. At NZP, the two-toed sloths also peacefully coexist with golden lion tamarins, acouchis, hairy armadillos, and a pygmy marmoset. All of these South American species share an exhibit that is profusely planted with tropical vegetation (real and artificial), creating the illusion of a tropical rainforest scene.

At present, the sloths' status in the wild is insecure. Like so many species native to the tropics, sloths still exist in large numbers but may soon be threatened by the destruction of their habitat. Fortunately, zoo breeding programs have been established throughout the world, and NZP has had success over the years, despite the difficulty of breeding this animal. (Not least among the problems is the fact that male sloths have internal testicles and females have a cloaca, making it almost impossible to tell the sexes apart just by looking. More than once, a "non-breeding male" has turned out to be a female on closer examination.) Other zoos, most notably the Buffalo Zoo and Lincoln Park Zoo, have also successfully bred two-toed sloths, thereby increasing chances for survival should this animal become endangered.

—Elizabeth Bromley

Jessie Cohen, NZP Graphics

NZP medalist Sir David Attenborough

NATIONAL ZOO MEDAL

On September 17, 1987, acclaimed documentary filmmaker Sir David Attenborough was awarded the National Zoological Park's medal for outstanding services to zoological sciences and conservation. Best known in the United States for his two natural history television series, "Life on Earth" and "The Living Planet," Attenborough recently published *The First Eden: The Mediterranean World and Man* (based on the 1987 PBS series) and has begun work on a new documentary film.

"David is unsurpassed in his ability to inspire an understanding of the world around us," said National Zoo Director Michael Robinson. "His books and television programs have instilled an appreciation of the intricacies of nature in millions of people."

The National Zoo medal was presented by Smithsonian Institution Assistant Secretary for Science David Challinor. The medal was previously awarded to Harvard University professor E. O. Wilson in May 1987 and to Indian Prime Minister Indira Gandhi (posthumously) in January 1986.

JAPANESE GIANTS

The National Zoo will soon have one of the few exhibits of giant Japanese spider crabs in the United States. On December 19, 10 of these impressive invertebrates were presented to the National Zoo as a gift from All Nippon Airways (ANA). Japanese spider crabs are the world's largest arthropods, sometimes reaching legspans of up to 11 feet. The Zoo's largest specimen currently has a legspan of about four feet.

As part of the gift, ANA will also fund the construction of a 3,500-gallon refrigerated marine tank to house the crabs at the new Invertebrate Exhibit. The permanent Japanese Spider Crab Exhibit is scheduled to open this spring. Until that time, some of the crabs will be on display at the Zoo, while the others are housed at temporary quarters at the New York Aquarium.

Japanese spider crabs (*Macrocheira kaempferi*) are endemic to the coastal waters of eastern Japan, where they live on the ocean floor at depths between 200 and 1,500 feet. In the spring, adult crabs migrate to shallower waters to mate and lay eggs. Females lay up to 1.5 million eggs at a time, although few young survive long enough to become adults. Japanese spider crabs mature at 10 years of age and may live more than 50 years.

RETURN OF A NATIVE

On November 13, 1987, 40 Jalak Bali flew from Los Angeles to the Javan city of Surabaja, the first of their kind to make a journey *to* rather than *from* Indonesia. Their flight on Indonesia's Garuda Airlines was the first stage in the planned reintroduction of zoo-born birds to the island of Bali, where only about 60 of these rare endemic starlings still survive in the wild (see *ZooGoer*, May-June 1987). It also marked the culmination of more than five years of planning for this complicated project, which was initiated at the National Zoo and ultimately involved the Government of Indonesia, the American Association of Zoological Parks and Aquariums (AAZPA), the International Council for the Preservation of Birds, and more than 142 zoos and private breeders here and abroad.

To honor the project's beginning, NZP Curator of Birds Scott Derrickson, on behalf of the AAZPA, presented the Indonesian Ambassador, His Excellency Soesilo Soedarman, with a Jalak Bali in a November 10th ceremony at the Indonesian Embassy. Riverbanks Zoo (South Carolina) Bird Curator Robert Seibels, the AAZPA's Species Coordinator for the Bali mynah, and Bronx Zoo Bird Curator Don Bruning, who worked out the final agreement, also attended. The presentation symbolized the commitment of all parties to the preservation of this uniquely beautiful bird in the wild.

Formerly residents of 10 different U.S. zoos, the 40 birds found a new home at the Surabaja Zoo, where large new enclosures for breeding pairs awaited them. By spring these pairs will have produced enough young for a first release in Bali. Young birds hatched in Indonesia's tropical climate are expected to tolerate a return to the wild better than those hatched in the temperate northern hemisphere; releasing the offspring rather than their parents also ensures that the health of the zoo breeding population will not be undermined if some of the released birds are lost.

Habitat destruction in Bali is largely responsible for Jalak Bali's near extinction, but until the late 1960s, when zoos learned to breed this species, trade in wild Jalak Bali for zoos and bird fanciers contributed to their decline. According to Species Coordinator Seibels, "This is one of the best chances for zoos to show that they are no longer consumers, but rather producers of critically endangered bird life."

NEW AT THE ZOO

Recent arrivals include a male lowland gorilla in the Great Ape House, an African lion in the Lion/Tiger area, a breeding pair of servals, a black-and-white ruffed lemur in the Monkey House, and zebra mice in the Small Mammal House.

Among new Zoo births were an orangutan in the Great Ape House, a white-cheeked gibbon in the Monkey House, and a Burmese brow-antlered deer in the Hoofed Stock Area. Two golden-headed tamarins and a Goeldi's monkey were among the newborns at the Small Mammal House, while young dwarf caimans and snake-headed turtles are highlighted at the Reptile House.

RESEARCH UPDATE

History and Heredity

Many zoo animal populations have histories—carefully documented rec-

ords of genealogies, movements from zoo to zoo or enclosure to enclosure, changes in diet, births and deaths. While these histories serve a number of short-term, practical purposes, they also prove invaluable to scientists. For example the written history of NZP's Dorcas gazelles allowed Katherine Ralls and her colleagues to document the deleterious effects of inbreeding on captive populations—and set off a revolution in the management of zoo animals.

Inbreeding is also thought to have negative effects on wild populations, but unless the history of a population is known it is hard to tell whether a particular species is somehow naturally low in genetic diversity or whether long-term inbreeding has occurred. This problem gained attention a few years ago when NZP scientists Mitchell Bush and David Wildt and their collaborator Steve O'Brien documented the near absence of genetic diversity in cheetahs, a phenomenon which was then correlated with reduced reproductive ability in both zoo and wild populations. But without being certain that cheetahs had once experienced severe inbreeding, and with no "normal" cheetah population for comparison, they could not be sure what caused these effects.

Thus when the opportunity arose in 1985 to study wild animals with histories—in this case lions—FONZ provided support and Bush, Wildt, and O'Brien headed posthaste for Tanzania. There, two populations of lions, one living on the Serengeti Plain and the other in the Ngorongoro Crater, have been followed by wildlife biologists continuously for more than two decades. What made these lions ideal for study is that the Ngorongoro population was known to have passed through a genetic "bottleneck"—the population nearly went extinct and then slowly recovered. Therefore all of these lions are descended from just a few individuals. In contrast, the Serengeti population has been large and healthy since record-keeping began. The researchers collected blood and semen samples from lions in both populations and found, as predicted, that the inbred Ngorongoro lions were less genetically variable and had more reproductive abnormalities than those on the Serengeti. For the first time ever, this effect had been documented in a known inbred wild population for which there were comparative data from a healthy population of the same species.

Last fall, with support from FONZ and the National Geographic Society, the trio returned to Tanzania, accompanied by Senior Research Assistant Steve Montfort and San Diego Zoo Associate Veterinarian Don Janssen. Following up their earlier work, the team collected blood samples from 64 male lions in the two populations. Through analysis of the samples, the scientists hope to discover the direct cause of the reproductive problems of inbred lions. One hypothesis they will test is that a hormonal imbalance is responsible for the males' abnormal sperm and low sperm numbers.

Spying on the Moles

It's hard to imagine a stranger-looking mammal than the star-nosed mole—unless it's a duck-billed platypus. It now appears that these animals may have more in common than bizarre appearance. Both species live in wet habitats—the platypus in Australia and the mole in North America; both forage during the night for aquatic invertebrates, earthworms and fish; and both may use electroreception—an ability more commonly associated with sharks and rays—to locate their prey.

Two years ago NZP's Curator of Mammals Edwin Gould began to study the life history of the star-nosed mole, a little known but fairly common insectivore of eastern North America. He also hoped to develop ways to maintain and exhibit these shy animals in the Zoo. The first obstacle, which Gould overcame in collaboration with FONZ-funded researcher William McShea, was simply to live-trap the moles so they could be brought to the Zoo or radio-collared for field studies. Then, using all the tricks of their trade and the new information from the field, Collection Manager Bill Xanten and keepers, particularly Grayson Harding, in the Small Mammal House developed techniques for zoo management and exhibition. At last, Gould could try to answer the question that most intrigued him. What is the function of the mole's unique star-shaped nose?

The first clue came recently and quite by chance, when German and Australian researchers demonstrated that the platypus's duck-bill serves as an electro-receptor organ that allows the animal to find food in the dark and underwater by sensing electric currents from its prey. Noting the parallels in ecology and behavior between these otherwise very dissimilar animals, Gould wondered whether the mole's star might also detect electricity. Gould enlisted the aid of Don Myer, a FONZ volunteer who also happens to be trained in physics and electrical engineering, and began to test this hypothesis.

Moles were presented with two hidden 1.5 volt flashlight batteries, one functioning and one not, and observed to see whether they responded differently—or at all—to the batteries. Preliminary results of this "choice-test" indicated that the moles *will* approach an electrical source and that they searched more often near the functioning battery than they did near the non-functioning one. A battery, however, provides an enormous electrical charge compared to that of a worm or a fish, so Gould emphasizes that the evidence is hardly conclusive. He plans to repeat the choice experiment using objects with electrical charges as low as those of the mole's prey and conduct further studies to determine whether moles can detect underwater prey at a distance. A study of the star's anatomical structure is also in the works. If further research supports this exciting early result, the star-nosed mole will be only the second mammal, after the platypus, found to be capable of electroreception.

—Daryl Boness
Department of Zoological Research and Susan Lumpkin

Edwin Gould

Star-nosed mole

TIGER, TIGER

Tigers of the World. 1987. R.J. Tilson and U.S. Seal (eds.). Noyes Publications, New Jersey. 510 pp. $64.00.

Since the onset of World War II, the world's population of wild tigers is believed to have dipped to a mere five percent of its estimated pre-war size. Over the past 15 years, however, tremendous efforts have been made to stem this downward trend. Wildlife biologists working in Nepal, India, and Russia have been in the vanguard of such attempts. Zoo-based biologists have also labored to increase our knowledge in the areas of veterinary medicine, reproductive biology, nutrition, and genetic management. I was therefore particularly pleased to note that five current staff members and three former research associates of the National Zoo were among the contributors to this volume. *Tigers of the World* derives from a 1986 symposium convened by the Minnesota Zoological Garden and the International Union for the Conservation of Nature to assess the current status of knowledge concerning the biology of wild and captive tigers. A total of 40 scientists contributed their knowledge; 14 countries, seven of which currently maintain extant populations of wild tigers, were represented.

The volume's seven sections address systematics and taxonomy, status in the wild, status in captivity, reproductive biology, captive management, white tiger politics, and conservation strategies. The section on white tigers is particularly instructive as this beautiful mutant has great public appeal but nonetheless is highly inbred and has doubtful value for the long-term survival of both captive and wild tiger subspecies.

Tigers of the World will prove invaluable to managers of captive feline populations, yet it should also interest lay readers concerned with the fate of the tiger. The book's publication alone marks a significant step in the formulation of a global conservation plan for wild tigers, and the text goes on to address the range of elements that affect the preservation of a large, wild species that has enormous space requirements in a world where wild lands are shrinking at an alarming rate. Indeed, the plight of the tiger at the close of the 20th century is shared by almost all large vertebrates situated at the top of the food chain.

Like lions, leopards, and grizzly bears, tigers capture mankind's attention because our encounters with them may prove life-threatening, and the chapters concerning human-tiger conflict are illuminating. When agricultural schemes involve land clearing and the destruction of the tiger's prey base, attacks on humans increase. Even without land clearing, the sheer number of humans in the forest increases the probability of an encounter, sometimes with unfortunate consequences.

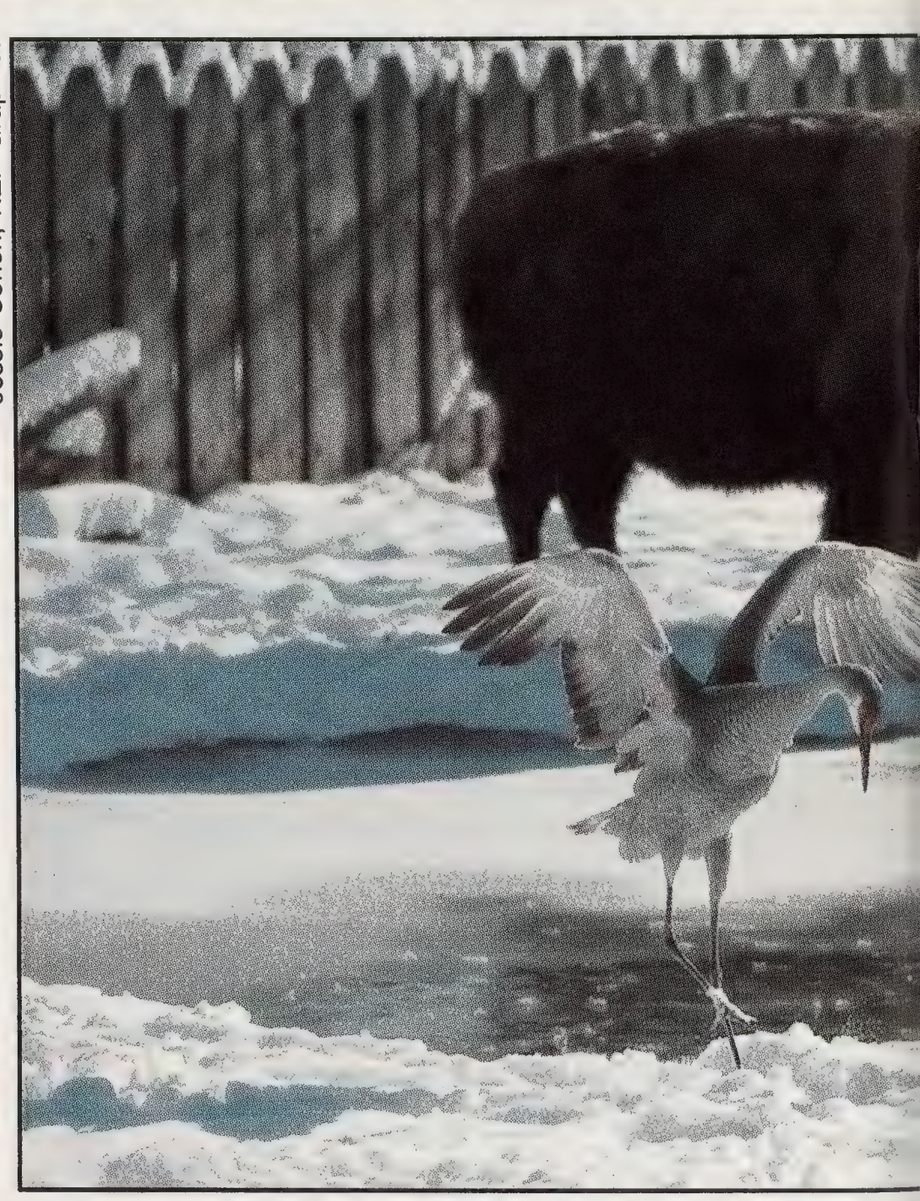
The conservation of the tiger in the wild has become symbolic of mankind's efforts to preserve functional ecosystems in the face of development. But it is not only predators that are at risk, for loss of habitat to people and development also threatens animals such as elephants, tapirs, and rhinos. In this regard, *Tigers of the World* pulls no punches but rather takes on the biopolitics of conservation without flinching. The sometimes conflicting needs of humans and wildlife are highlighted in the final section, and the various authors remain hopeful that a rational solution may yet be found. The "global conservation plan" offers a small ray of hope for both tigers and humans. It could pave the way for a reversal in current trends set in motion by our species that may otherwise result in the irreversible deterioration of the biosphere.

—*John F. Eisenberg*

FOCUS ON PHOTOGRAPHY

Winter is a wonderful time to photograph the many zoo animals that remain outdoors and active in the cold weather. American bison, Bactrian camels, timber wolves, waterfowl, and even Barbary macaques pose good possibilities for winter photographers. With few visitors to work around, the perfect shot of courting camels or giant pandas at play may be at your fingertips—and knowing which lens to choose could make all the difference.

A 70 to 210 mm zoom is one of the most useful lenses for photographing zoo animals in outdoor exhibits. This lens often allows you to fill the frame with an animal, and is easier to use than a longer, heavier telephoto lens. When shooting ducks or swans from a fixed position, you can follow the birds by zooming in and out as they move closer or farther away. Remember, animals in motion require a shutter speed fast enough to freeze the action—at least 1/250 of a second.



Jessie Cohen, NZP Graphics

American bison and sandhill cranes

If you wish to isolate the animal from its background, either the zoom or a 200 mm lens would be a good choice. I generally use a 200 mm lens to shoot animals like wolves, which are often curious and will approach the front of their enclosure. (Use a wide angle or normal lens if you want to include the wolves taking a drink from their pool and show the naturalistic background.) A 300 or 400 mm lens would be most suitable for a portrait or especially tight shot. A less expensive alternative to very long lenses is a telextender or doubler, which doubles the focal length of the lens that you use it with. For example, a 200 mm lens becomes a 400 mm lens with a telextender, and the wolf becomes twice as large in your photo. The

photographed in the snow at NZP.

telextender also doubles the f-stop and makes the viewfinder less bright. Telextenders made by your camera's manufacturer are usually the sharpest.

To take sharp photographs when using a telephoto lens, you must use a shutter speed fast enough to prevent camera shake. I use a shutter speed that is nearest to twice the focal length of the lens. For example, if I am using a 200 mm lens, I never hand-hold it using a shutter speed slower than 1/500 of a second. If you need a slower shutter speed, use the guard rail or a tripod as a camera support. When using a tripod in cold weather, avoid freezing your hands to the metal by wearing gloves with the ends of the fingers cut out or silver glove liners made for cross-country skiing. Your hands will stay warm and you will still have the dexterity needed to work the camera or tripod controls.

Winter weather conditions provide challenges and unusual photographic possibilities. A snow-covered exhibit makes a great photographic background that shows off the animal. Try taking advantage of a plain white background of snow to create interesting compositions using the shapes and patterns of zebras or giant pandas.

Metering in snow can be tricky. Your exposure depends on the lighting conditions and the color of your subject. Your camera's meter typically exposes for medium gray, so the white snow may trick the meter into underexposing the photo. Instead, you may wish to meter on an object or animal that is mid-toned and in the same lighting as your subject. Use that reading as a guide and bracket your exposure.

To avoid disappointment, carry extra batteries and keep your camera inside your coat when not in use as the cold tends to drain batteries faster than usual.

When you are ready to warm up, use your shorter and macro lenses indoors at the Invertebrate Exhibit and Small Mammal and Reptile Houses, where the enclosures are smaller and the animals are closer.

—Jessie Cohen
NZP Photographer

KEEPER'S CORNER

A visitor's perspective is often colored by her frame of reference. This is understandable. You can imagine our amusement, however, when a visibly upset woman ran into the Reptile House one summer day and informed us that a male giant tortoise (which was in the process of mating with one of the smaller females) was "stuck on a rock."

—Bob Davis
Reptile Keeper

FONZ/ZOO NEWS

The newly expanded FONZ Bookstore has re-opened in the Education Building. Carrying an in-depth selection of natural history books, gifts, and crafts for all ages and interests, the store is open 10 a.m. to 4 p.m. during the Zoo's winter hours.

The National Zoo will celebrate Seal Day on Sunday, March 6, from 11 a.m. to 4:30 p.m. in Beaver Valley. The hooded seal is the focus of this year's event, which features animal demonstrations, tours of the filtration room, and a life-sized model of a male hooded seal. For further information, call 673-4955.

The 1987-88 Sunday Afternoons at the National Zoo series wraps up on March 13 with the screening of "Star Trek IV: The Voyage Home," in which the crew of the Enterprise returns to present-day Earth and becomes involved in a conservation crisis. The movie will be shown at 1 p.m. in the Education Building auditorium. Free tickets are required and must be picked up in person from the Information Desk.

The National Zoo and the Children's Theatre of Arlington's Repertory Company will join forces to present "The Tamarin Trickster," a lively, conservation-oriented play for families. Adapted from "Artes e Manhas do Mico-Leao," a script originally produced as part of NZP's Golden Lion Tamarin Conservation Project in Brazil, the play uses animal characters to present the plight of the world's rapidly vanishing tropical forests. Performances will take place Friday, March 18 at 7:00 p.m. and Saturdays, March 19 and 26, and Sundays, March 20 and 27, at 2:30 p.m. Free tickets may be picked up at the Information Desk beginning March 11. For further information, please call 673-4717.

Elephant researcher and author Cynthia Moss will give a free lecture at the National Zoo on Sunday, March 20, at 7 p.m. A reception will precede the lecture at 6 p.m. and a booksigning of Moss's recently published *Elephant Memoirs* will follow. For reservations, call 673-4960.

ZOOFARI, "MATES"

Marvelous marsupials and captivating kookaburras will be highlighted at this year's ZooFari gala, which celebrates Australia. Featuring behind-the-scenes tours, animal demonstrations, cocktails, a silent auction, dancing, and an outback barbecue, the 1988 ZooFari will again benefit the National Zoo's Theodore H. Reed Animal Acquisition Fund. ZooFari will be held the evening of Thursday, May 26, on Olmsted Walk near the new Gibbon Exhibit. Tickets are $75 per person. To receive your invitation, please call 332-WILD.

After Many a Summer Lives the Swan

Susan Lumpkin

As we inched along a Centennial Valley dirt road rendered nearly impassable by a summer shower, my father-in-law told old stories about delivering babies in this remote Montana valley. More often than not it seemed, he delivered them in the winter—by telephone. In the summer he might have covered the 70 or 80 miles from his home in Dillon in time (no physician lived any closer), but from November until May the valley was snow-bound. Only on a snow-plane, or more recently, a snowmobile could anyone hope to get in—or out. This remains true, although the valley's tiny population now mostly clears out for the winter. The valley is left in splendid isolation.

But it is far from uninhabited. Golden eagles soar the big sky. Moose paw through powdery snow to find small plants. Beavers give birth and gnaw on the aspen they've stored in their lodges. Great horned owls hoot to break the night's silence. And trumpeter swans, hundreds of trumpeter swans, herald the dawn with haunting calls as clear as the notes of a French horn. They might be proclaiming their undisputed possession of the valley in winter. For these reclusive birds, isolation is not only splendid—it is essential. The solitude they found or more accurately, never lost, in the Centennial Valley is what makes possible their survival in the United States outside of Alaska.

Trumpeters (*Olor buccinator*) are the largest of the swans, the largest of all North American waterfowl, and the heaviest of all North American birds. Measuring as much as four feet from bill to tail and weighing 20 to 30 pounds or more, these swans create waves rather than ripples when they land on a still pond. Their wings span up to eight feet. They are breathtaking in flight. It seems only natural that sighting a trumpeter should be a special pleasure, something possible only on a remote northern lake.

Yet it is not natural. Trumpeter swans were once common and abundant in the United States. Although their breeding range appears to have been limited to the northern tier of central and western states, perhaps including Indiana and Missouri, they wintered much farther south and east. The first mention of trumpeters by colonial settlers was made in 1632 by a New England historian, who correctly called them the biggest of the new country's birds. The next mention was in 1709, when a North Carolina surveyor described great flocks of trumpeters wintering along the central Atlantic seaboard. Subsequent records place wintering trumpeters in the Ohio and Mississippi River Valleys and perhaps in estuaries along the Gulf of Mexico.

Ominously, however, most of these accounts also made note of the value of the trumpeter's flesh ("a delicate dish") and skin ("a commodity, fitt for divers uses, both for fethers, and quiles"). And in the next historical mention of trumpeters, in 1795, Samuel Hearne, an explorer and employee of the Hudson's Bay Company, noted that trumpeters loomed large in trade between the Hudson Bay Indians, who took them for food, and the Company, which marketed their skins. Thirty years later, the first references to swans being traded in the United States appeared. Audubon, for instance, described Indians hunting swans to provide skins "for the ladies of Europe." Although it hardly rivaled the trade in North America's fabulous furs, trade in trumpeters was big business throughout the 19th century.

Between 1823 and 1880, the Hudson's Bay Company alone sold some 108,000 skins on the London market, most of which were fashioned into powder puffs. Feathers adorned hats

Jessie Cohen, NZP Graphics

The trumpeter swan is North America's—and NZP's—largest waterfowl species.

and even trumpeter quills were in demand. They made excellent pens, which Audubon preferred to all other instruments for drawing the fine details of his birds. Beyond the recorded trade, countless other trumpeters were taken for local consumption. By 1880, however, the trade was on the decline. Trumpeters had become too scarce to hunt profitably.

During the same period, settlement of the prairies and the great plains also took its toll on the trumpeter swan. As farms and ranches replaced marshes and wet meadows, prime trumpeter breeding habitat was destroyed. The birds that did try to breed on the remaining ponds were disturbed by human activities. Mated pairs of trumpeters require large secluded territories to nest successfully. Although they aggressively defend 30 to 100 acre ponds or marshes from other trumpeters and large birds, more threatening intruders—like people—cause the swans quietly to leave and wait out the intrusion. Repeated disturbance eventually leads to the pair's abandoning the site; if other suitable areas are not available, the pair simply does not breed.

By the early years of the 20th century, there was little hope for the trumpeter swan's survival. William Hornaday, who helped found both the National and the New York zoological parks, considered the swan's demise inevitable, as did ornithologist Edward Howe Forbush when he stated in 1912 that their "total extinction is now only a matter of years." (Trumpeter swans were not alone: Elk, bison, beaver, bighorn sheep, pronghorn antelope, whooping cranes and sage grouse were just a few of Hornaday's American "candidates for oblivion," believed destined to follow great auks and passenger pigeons into extinction.)

In 1919, a small breeding population of trumpeters was discovered in Yellowstone, where wildlife had been protected from hunting since the park's establishment in 1872. Furthermore, the Migratory Bird Treaty Act, a landmark piece of conservation legislation, had extended protection to swans outside the park in 1918. But this did not change the perception that trumpeters were doomed. Arthur Cleveland Bent, in his 1925 life history account of the species, held out little hope for the trumpeter swan's survival.

John Seidensticker

Jessie Cohen

Jessie Cohen, NZP Graphics

Trumpeter swans require rich, undisturbed marshes like those of Red Rocks Lakes (top). Yellowstone provides winter habitat for trumpeters (middle). NZP was among the first zoos to receive swans from the Red Rocks refuge (bottom).

By the early 1930s, only a few swans were known to exist in western Canada, and a few more—69 to be exact—in the contiguous United States. Thirty-one of these were in Yellowstone and twelve more dwelt in scattered sites outside the park. The rest—19 adults and seven swan cygnets—lived in the Centennial Valley, on high mountain marshes known as Red Rocks Lakes. To better protect this fragile population from illegal hunting, these 14,000 acres of shallow lakes, fertile marshes, and sedge meadows were acquired by the Federal government in 1935, and Red Rocks Lakes was established as one of the nation's first migratory wildfowl refuges.

Red Rocks Lakes was—is—ideal trumpeter swan breeding habitat. Trumpeters subsist almost entirely on aquatic vegetation, which grows profusely in these rich lakes and marshes—an essential requirement when a single adult bird eats up to 20 pounds of herbage each day. Most of the lakes are only a few feet deep, allowing the swans easily to dig out nutritious roots and tubers. Although they are shallow, the lakes never dry out, since their waters are constantly replenished by springs and by melting snow from the Centennial Mountains.

Perhaps more important, the area provides equally good wintering habitat for trumpeter swans. In Red Rocks itself, warm springs keep two small ponds, about 10 acres total, open and vegetated all winter. About five miles from the refuge, just across the Continental Divide in Idaho, numerous warm springs keep hundreds of acres of river and ponds along Henrys Fork of the Snake River unfrozen—and plants growing—even in the coldest weather. Waters open in winter are also found in at least five sites in Yellowstone and two others just outside the park. As a result, the trumpeters of the "greater Yellowstone ecosystem" do not migrate; all live out their lives within a few miles of home. In fact, this was key to the trumpeters having survived in Red Rocks and in Yellowstone long after the rest of their kind disappeared. While low-flying flocks of swans migrating from remote breeding sites to warm wintering grounds generally found their traditional routes paved with hunters, the non-migratory Yellowstone swans were spared from running this annual shotgun gauntlet.

Protection from hunting was not the only advantage of the establishment of the Red Rocks Lakes Refuge. The U.S. Fish and Wildlife Service (then called the Biological Survey) immediately began management of the refuge to enhance the trumpeter's preservation. People were forbidden to enter swan breeding waters. (Limited cattle grazing on adjacent meadows was allowed, however, so as not to alienate the valley's ranchers, many of whom had earlier protested the illegal hunting of "their" trumpeters and actively supported the efforts of wildlife managers to preserve Red Rocks for the swans.) Refuge managers provided grain to supplement winter food supplies for the swans. Even muskrat trapping was regulated because trumpeters often nest in old muskrat houses, and over-trapping of muskrats had reduced the number of houses left for swan nests.

So successful were these measures that as early as 1938, four cygnets born at Red Rocks were transplanted to the National Elk Refuge near Jackson, Wyoming, to begin the process of restoring trumpeter swans to their original U.S. breeding range. Today about 500 trumpeter swans live in the greater Yellowstone ecosystem, 300 of these in the Centennial Valley. When migrants from Canada (where trumpeter numbers have also increased due to conservation efforts) arrive to take advantage of the area's warm winter waters, the number of swans swells to about 1,500. Transplants from Red Rocks have established small breeding populations on refuges in Wyoming, Washington, Oregon, Nevada, Minnesota, and South Dakota; unaided, South Dakota swans have moved into Nebraska. Conservation programs are now underway to reintroduce trumpeters to additional sites in Missouri, Michigan, and Wisconsin.

Although the trumpeter swan is no longer considered an endangered species in the United States, this is not because the swans of the contiguous U.S. are entirely secure—they are not. But in the 1950s just as the Red Rocks restoration program was roundly declared a success, biologists finally began to explore in depth the Alaska wilderness. To the astonishment of the world—or at least ornithologists and wildlife biologists—thousands of trumpeter swans were found breeding in Alaska's high mountain valleys, from the Arctic Circle to the Gulf of Alaska. Ornithologists had previously assumed these swans were whistlers, a smaller swan species very similar in appearance to trumpeters. These trumpeters winter in southern Alaska, British Columbia, and Washington, where for years they'd been mistaken for the whistlers that also winter there. Simply finding and correctly identifying Alaska's trumpeter swans increased the number of swans believed alive in the United States to about 10,000 in the 1980s!

Nonetheless, this does not reduce the significance of the Red Rocks conservation success story. The Alaskan and southern trumpeters are quite distinct populations. Birds from the two populations have probably not interbred for thousands of years and Alaskan trumpeters show some unique genetic variability. But population genetics aside, a trumpeter in Alaska is not a trumpeter in Montana or Minnesota or South Dakota—and trumpeter swans *belong* in all of these places. Moreover, trumpeter swans everywhere must still be protected from human activities—housing development, logging and road-building, winter recreational activities, even man-induced climate change—if they are to survive in the nation's no longer isolated mountains and forests.

Of course, the trumpeter swans are not the only beneficiaries of protection and management at Red Rocks Lakes. In summer, the Centennial Valley teems with wildlife. Coyotes wander among the placid cows that still graze there. Long-legged sandhill cranes dance their courtship display in the marshes and meadows. Foraging pronghorn antelope suddenly bound into startled flight at some disturbance. Young red fox play with abandon in broad daylight. Marmots whistle and ground squirrels chatter in fields painted red, yellow and blue by wildflowers. Mountain bluebirds, black-billed magpies and yellow-bellied sapsuckers flit through groves of quaking aspen. Great blue herons stalk the edges of the lakes, which are thick with waterfowl. White pelicans, pied-billed grebes, and goldeneye ducks swim among hundreds of other waterbirds. And apart from the crowd, proud trumpeters lead their broods of downy cygnets through the marsh. We can see all this on a short visit. We are the beneficiaries. □

Animal Rights and Human Wrongs

The spectrum of people concerned about the welfare of animals is very broad indeed. It runs from those concerned about the fate of species to those worried about individual animals, and from environmentalists to vegetarians . . . and these categories are not even mutually exclusive. The philosophies of animal lovers differ as broadly as their concerns. One currently conspicuous philosophy is that of animal rights, which may translate into practical action as movements for "animal liberation." In the last few years the animal rights movement has acquired considerable impetus and, in some of its expressions, has moved beyond conventional democratic means of protest. It has used aggressively interventionist tactics including vandalizing laboratories, destroying research materials, and stealing animals. These actions should not be used by people who oppose such methods as a pretext for ignoring or prejudging the *issues* involved. Abuses of *human rights* excite our passions. In this context, we should realize that it is very difficult for anyone who loves animals to countenance their deliberate abuse. I find I am angered by blatantly insensitive attitudes to animals when I eavesdrop on the conversations of some of our zoo visitors, but more of that later. There are some major philosophical and moral questions provoked by the animal rights movements: what constitutes abuse, do animals have rights, and from what are they to be liberated?

These are all valid questions but they are by no means easy to answer. They are complicated by the fact that the word "animals" does not encompass a unitary phenomenon. The world of animals consists of millions of species, hugely varied in habits, habitats, organization, and nervous systems. Despite advances in biology, the question of whether consciousness exists in even a tiny fraction of species is totally un-answered. This is one caveat. But even if animals were human beings, about whom we know more, there would still be complex philosophical problems involved in deciding what constitutes abuse. On the issue of human rights there is a huge spectrum of differing opinions, and the question of what constitutes freedom is perhaps the most contentious issue of our time. Libertarians equate freedom with the absence of restraint and protectionists argue that freedom for the largest number of people involves restricting certain "liberties." How much more difficult it is to apply such concepts as freedom to other species. Evaluating the "inalienable rights" of non-human animals inevitably generates profoundly differing opinions. These opinions are influenced by religion, politics, passions, and prejudices. I have my own views on ethics but these do not derive from my position as an experienced biologist and Zoo Director. They are those of a private citizen and not germane here. However, what I can say legitimately, as a biologist, and particularly as an ethologist, is that many people confound the issues involved because they do not understand the animal's world.

The Equatorial Jungle; Henri ROUSSEAU; National Gallery of Art, Washington; Chester Dale Collection.

Misperceptions based on projecting human feelings onto animals abound. These misperceptions belong to the widely cited but grossly underestimated fallacy of anthropomorphism. This is the process of assuming that other animals are just like us. It is almost as bad a mistake as assuming that all animals are alike. Not all misconceptions about animals are as complex as these two. When somebody complains that our giant panda is stressed-out, because they have seen her lying on her back "utterly exhausted," this is a simple *misobservation*, and I can point out that pandas only lie on their backs, sleeping, when they are utterly free from stress and fear. The correct conclusion is that the animal is relaxed completely. On the other hand when somebody writes that our golden lion tamarins are "imprisoned" in a cage smaller than the "average bedroom," *then* they are guilty of anthropomorphism. For a start, the animal is only a tiny fraction of our size and weight. To appreciate the true size of its enclosure we should multiply it by a factor equal to our size difference. Since unlike ourselves, it is not confined to the two-dimensional floor, we should also add factors for the area of climbing surface and volume of jumping space available to the animal. But even that is not enough. There is an assumption that wild tamarins are "free" (implied by the use of the antonym "imprisoned"). This I call the Rousseau fallacy, from the famous aphorism of Jean Jacques Rousseau: "Man is born free but is everywhere in chains." Applied to the original condition of man, this is a naive and dubious proposition, but applied to the wild state of animals, freedom is a meaningless abstraction. This biological observation should be pondered well. In the wild, social interactions between animals as complex as tamarins are almost certainly horrendously fear-inducing, frustrating, aggressive, stressful, and competitive. Survival is a constant struggle; lives are short and seldom sweet. Is any animal "free," in a meaningful sense of the term, when it lives in a constantly fluctuating matrix of territories, competitive struggles, food shortages, and the constant danger of predation? Wherever good data exist we can say that almost all the species of animals in the National Zoo live longer than their wild counterparts. They breed more often and produce larger litters. Indeed, as habitats are destroyed in the wild, zoos may be the only places where some species can be preserved. This may be the ultimate freedom: Freedom from extinction.

These are not mere rationalizations to justify the status quo. They are true of the majority of animals, but only true because of animal husbandry. The single animal exhibits of the past were abominations and forced groupings of inimical individuals were extremely stressful. But if you want to reflect on life in Rousseau's innocent paradise, think only of the polar bears that parasitize the town dumps in Alaska. They are so driven by hunger in the wild that they have to overcome their extreme fear of the noise and odors of urban environments. They then gather in stressful densities to feed on unnatural food. Think of the overriding hunger needed to overcome so much inhibition. Similar things happen to baboon groups in Kenya and were a regular feature of life of that magnificent animal, Baird's tapir on Barro Colorado Island in Panama. The dry season there is one of food shortages for such big herbivores, and for many other less conspicuous animals. The tapirs came to the research center's kitchen daily, to mooch loaves of white bread. They stood there patiently, against all instincts except hunger, waiting for handouts—covered with innumerable ticks and debilitated by parasitic worms. Should we thus have saved them year after year from *natural death* by starvation? Did we deny them freedom? This is a real dilemma, of application to many species in contact with the effects of *our* civilization. We have to ask whether in the absence of natural population controls, we maintain, by the supplementary feeding of wild animals, populations that are totally unnatural? Such populations exceed the natural resource base. Should we really feed wild birds in the winter when winter deaths were "nature's pruning hook?" Do the overlarge summer populations that result eventually lead to disastrous ripple-effects? Do we cull elephants in reserves when they start to overeat their very slowly renewable resources? These questions cannot be answered at an emotional level, and certainly are not susceptible to simplistic analysis.

There are of course more issues than this, and one is important to our exhibit philosophy at the National Zoological Park. We design many exhibits to please visitors as well as the animals. We produce human's eye views of habitats with naturalistic stones, growing plants, and artfully reconstructed mural landscapes. But this may strengthen the very anthropomorphisms that lead to misconceptions about animals. Perhaps we should produce some monochrome exhibits to show visitors that many animals do not see colors? Perhaps we should produce some out-of-focus exhibits to show that many animals have fuzzy vision? Perhaps we should produce a scaled-up exhibit to show how gigantic a tree is to an elephant-shrew? We must do more to put humans into the perceptual world of animals. Only then can we appreciate their stresses, terrors, sensations, and motivations. Only then can we have an understanding of why we should treat animals with respect.

We still have to solve human rights issues, but someone has to speak for the animals from individuals to species. Both tasks are urgent but species are irreplaceable and their salvation will require much more than individual concern. Our civilization leads to increasing technological development, called progress. But can progress be allowed to replicate the great extinctions of plants and animals that marked the end of the Mesozoic period? Are we to be destroyers of life on a global scale comparable to Nemesis, the death star?

—*Michael Robinson*

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